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VOLUME 26
NUMBER 2

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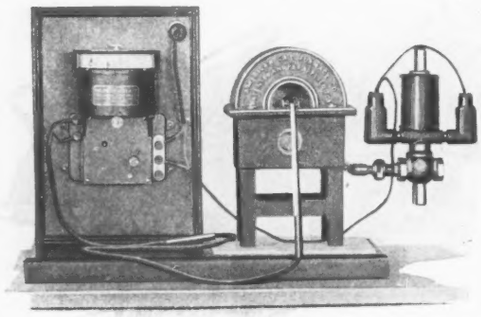

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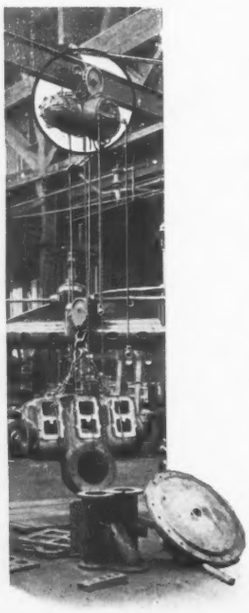

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Turret Lathe Practice

By Erik Oberg

Examples of Turret Lathe Practice Based Upon the Experience and Practice of the Service Department of the Gisholt Machine Co., Madison, Wis.—First of a Series of Four Articles on Turret Lathe Tooling Equipment

THE work that may be performed on turret lathes has been dealt with in the past only by occasional articles in the trade and engineering press. On account of the importance of the turret lathe in the modern machine shop and the possibilities that this machine tool presents for the rapid and accurate production of work that, when performed by other methods, would become much more costly, a more comprehensive treatise on this subject is required.

Because of the character of the work performed on the turret lathe and the very important part that the lay-out of the various operations and the tooling equipment play in successful turret lathe practice, it has been deemed advisable to deal with this subject by presenting actual examples, showing the complete tooling lay-outs, giving detailed descriptions of the order of operations and methods of holding the work, together with photographs showing the machines actually set up with the tooling equipment and the work in place. The examples that have been selected are those for which the turret lathe is especially suited, and where the saving of time is the greatest. The series of articles beginning in this number of MACHINERY, dealing with turret lathe practice, will cover tooling lay-outs and orders of operation for flywheels, truck wheels, automobile engine cylinders, cone clutch parts, motor frames, axle housings, wheel hubs, and valves.

In addition, examples of work will be shown which can be successfully performed on a turret lathe, although the work might also be performed on other machine tools. There are, for example, many instances when a turret lathe will not continually be kept busy on the work for which it is primarily installed and on which the greatest saving is

The Gisholt Machine Co. maintains a service department engaged in the solving of difficult problems in machining work on the turret lathe for its customers. Providing, as this service department does, the solution for between 800 and 900 such problems annually for its customers throughout the industrial world—including the laying out of tooling equipments for performing the various operations, outlining the methods for obtaining maximum production, building and testing all the tooling equipments thus planned and designed, and training operators for the company's customers in a special training school in order to insure the proper maintenance and use of the machines and the equipment—it is evident that a vast amount of accumulated data was available from which the information required to make this series of articles comprehensive and instructive could be drawn. The illustrations have been selected from a file of 4000 photographs kept by the service department as a record of past performances, every tooling equipment, when tested out in the company's plant, being photographed for a permanent record which can be consulted at any future time.

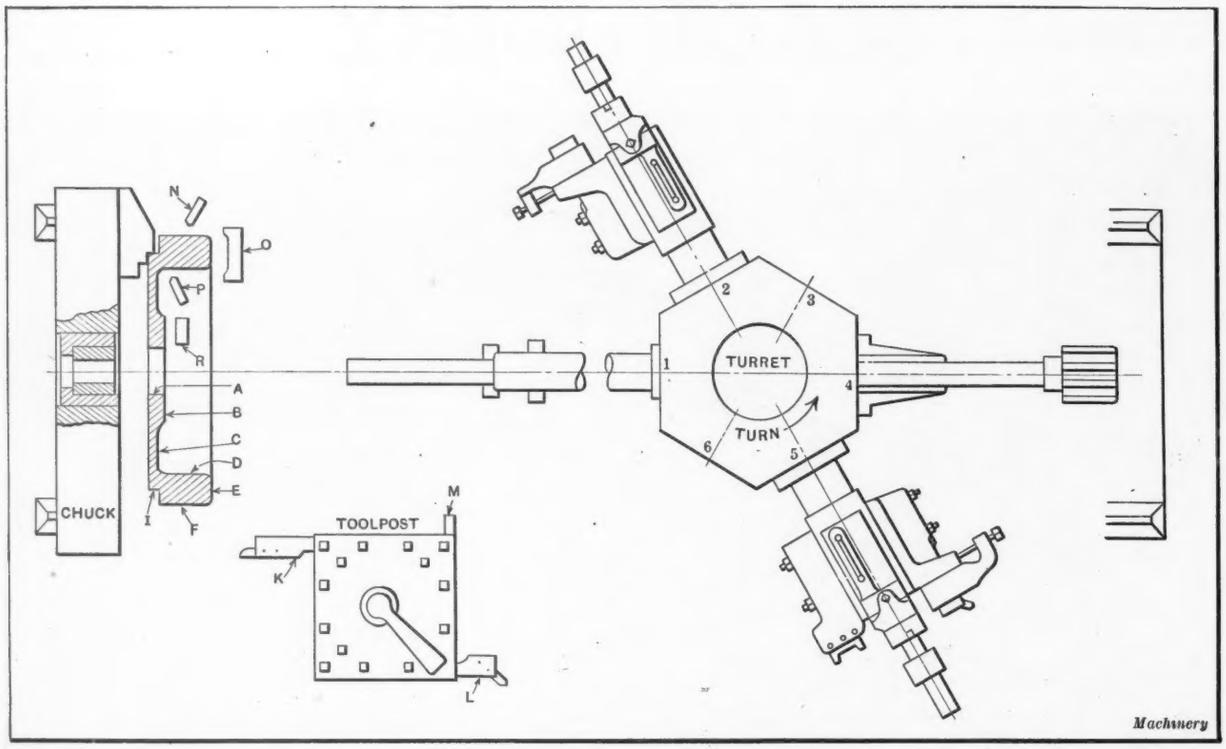

Fig. 1. Tooling Lay-out for First Operation on Flywheel

accomplished. In that case, it is evidently of advantage to fill in the idle time with such work as can be performed satisfactorily on this machine, although the machine would not have been bought for this work exclusively.

In dealing with the examples of turret lathe practice that will be explained in the following, the time for each operation is given; this time is the "floor to floor" time and includes the time required for chucking the work in the machine and for removing the finished part. The material from which the various parts, the machining of which is described, are made is also given, so that all the factors involved may be properly understood. The great detail in which the sequence of operations (or steps in each operation) is given will make it possible to follow thoroughly the methods used in machining. It is believed that a careful study of the sequence of the various steps in performing the machining work will give the reader a comprehensive idea of the principles involved in turret lathe tooling, and enable him to understand the reasons underlying the selection of various tools and the order in which they are used.

Tool Lay-out for Finishing Flywheels

Fig. 3 shows a flywheel used in connection with an electric starter for an automobile. This flywheel is finished all over in two operations, the tooling lay-out for the first operation being shown in Fig. 1, and the lay-out for the second operation in Fig. 2. A photograph showing the tooling for the first operation is shown in Fig. 4, and for the second operation, in Fig. 5. There is a slight modification in the arrangement in Fig. 4 as compared with Fig. 1. Side 2 of the turret in Fig. 1 has the turning tool in the front arm of the facing head, while in Fig. 4 it is shown in the rear. Side 5

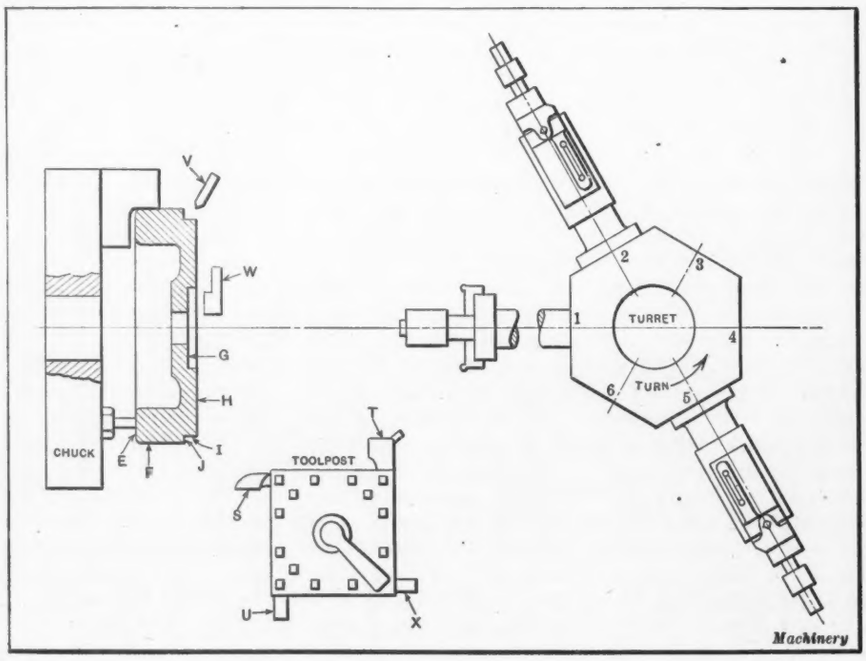

Fig. 2. Tooling Lay-out for Second Operation on Flywheel

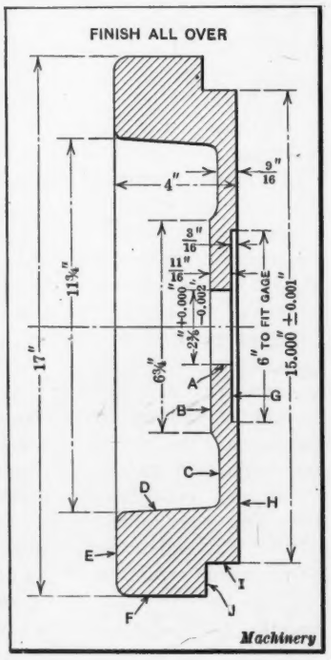

Fig. 3. Drawing of Flywheel

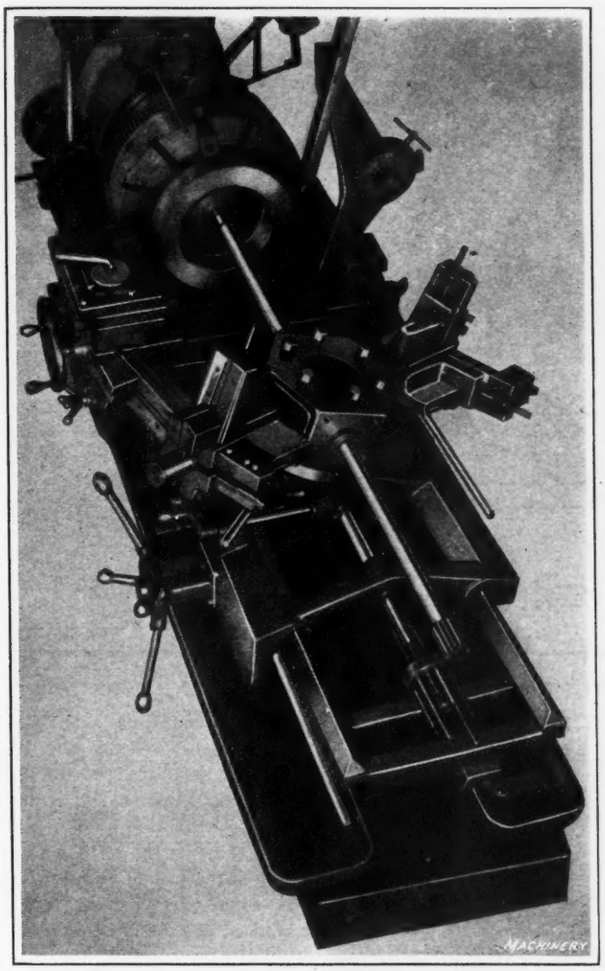

Fig. 4. Machine set up for performing First Operation on Flywheel

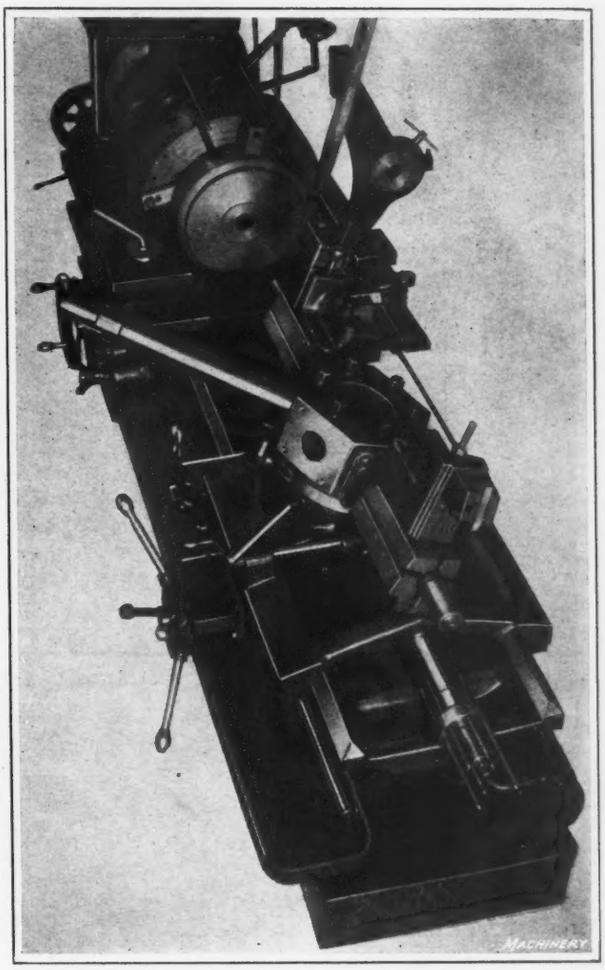

Fig. 5. Machine set up for performing Second Operation on Flywheel

of the turret in Fig. 1 also shows the cutter in the front arm, while in Fig. 4 it is shown in the rear arm. Fig. 6 shows a detail view of the work as held in the first operation with the boring-bar for the hole just entering the work, while Fig. 7 shows a detail view of the work as held for the second operation, the bar and tool for finishing the counterbore being shown as it is being withdrawn from the work. These views are so clear as to require but little explanation.

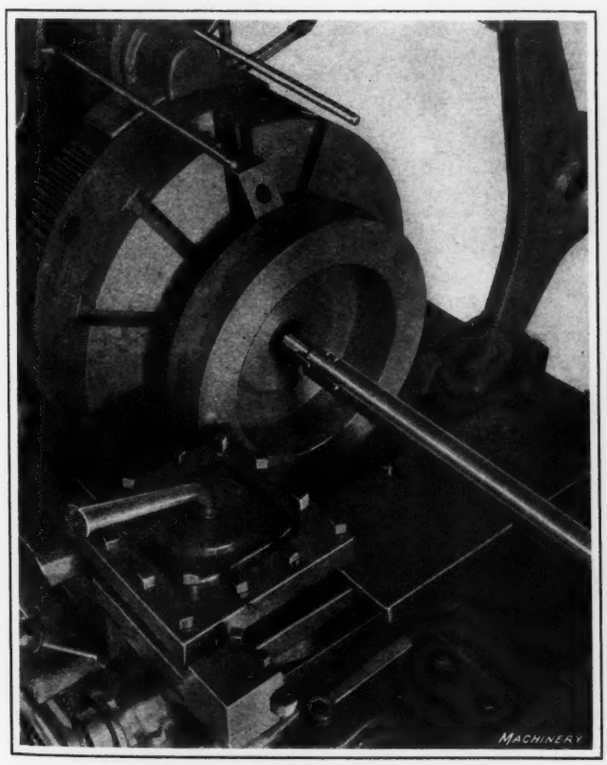

Fig. 6. Detail View of Work as held in First Operation

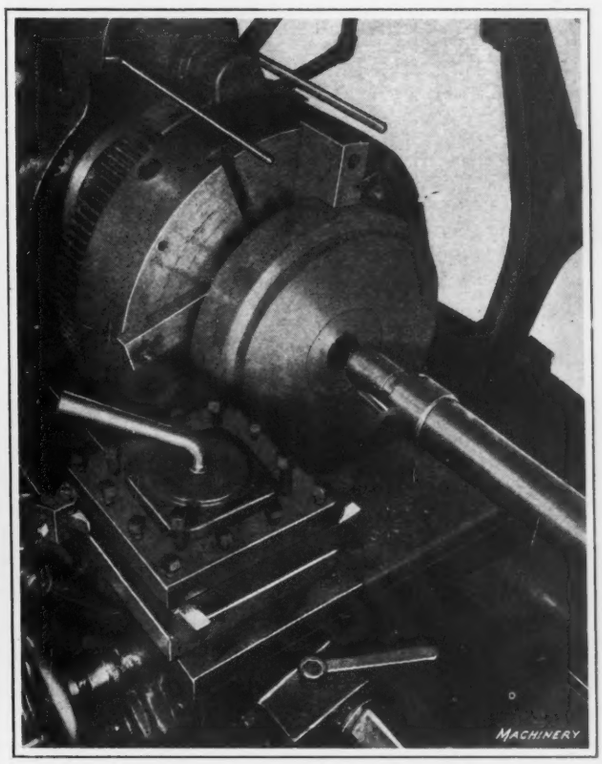

Fig. 7. Detail View of Work as held in Second Operation

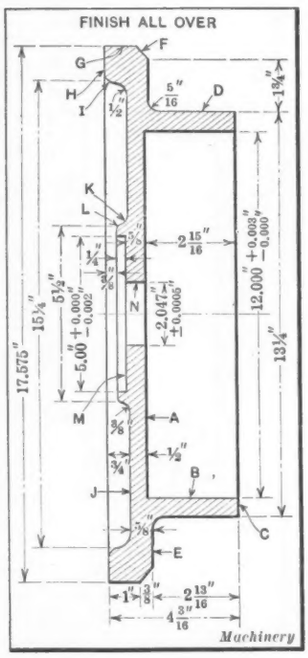

Fig. 8. Automobile Flywheel

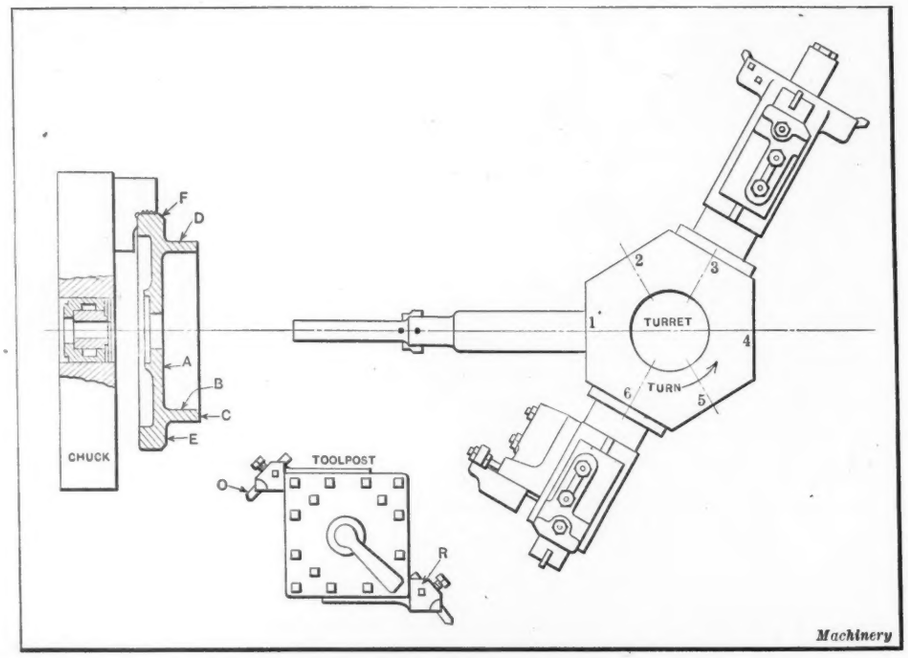

Fig. 9. Tool Lay-out for First Operation on Flywheel in Fig. 8

This work as shown is performed on a 24-inch Gisholt turret lathe. The material of the flywheel is cast iron. The first operation, Fig. 1, consists in finishing surfaces *A*, *B*, *C*, *D*, *E*, and *F*, the order of operations being as follows: (1) The work is held in the chuck by special hard jaws clamping on surface *I*. (2) Hub *B* is rough-faced by tool *K* in the toolpost. (3) Surface *C* is faced by the same tool. (4) Surface *D* is rough-bored by still using tool *K* in the toolpost. (5) Finally, surface *E* is faced by tool *K*. (6) Hole *A* is rough- and finish-bored by the boring-bar in Side 1 of the turret. (7) Hole *A* is reamed with the reamer held in Side 4 of the turret. (8) The outside surface *F* of the flywheel is rough-turned with tool *L* held in the toolpost, followed by the facing head mounted in Side 2 of the turret. (9) The outside surface *F* is finish-turned, surface *E* is faced and the corners rounded, and surface *D* is finish-bored with the facing head mounted in Side 5 of the turret. It will be noted that in Operation (6)

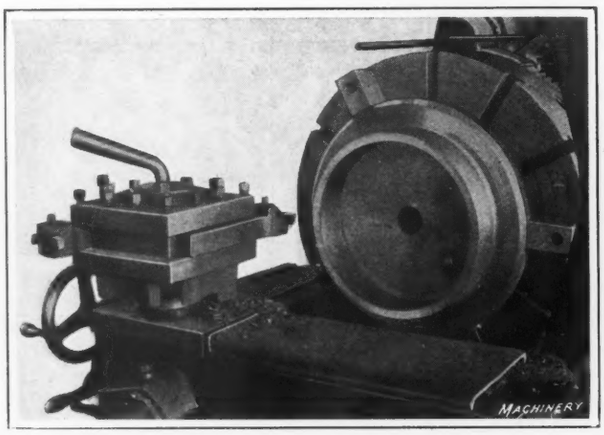

Fig. 10. Method of holding Flywheel in First Operation

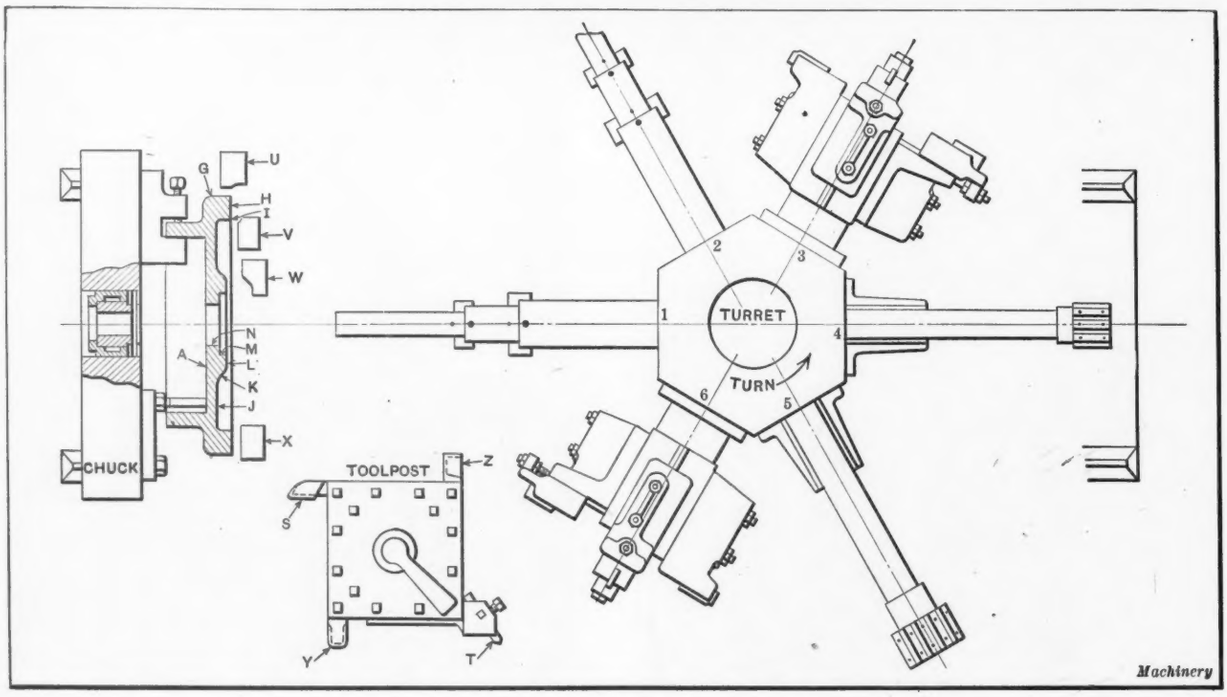

Fig. 11. Tool Lay-out for Second Operation on Automobile Flywheel

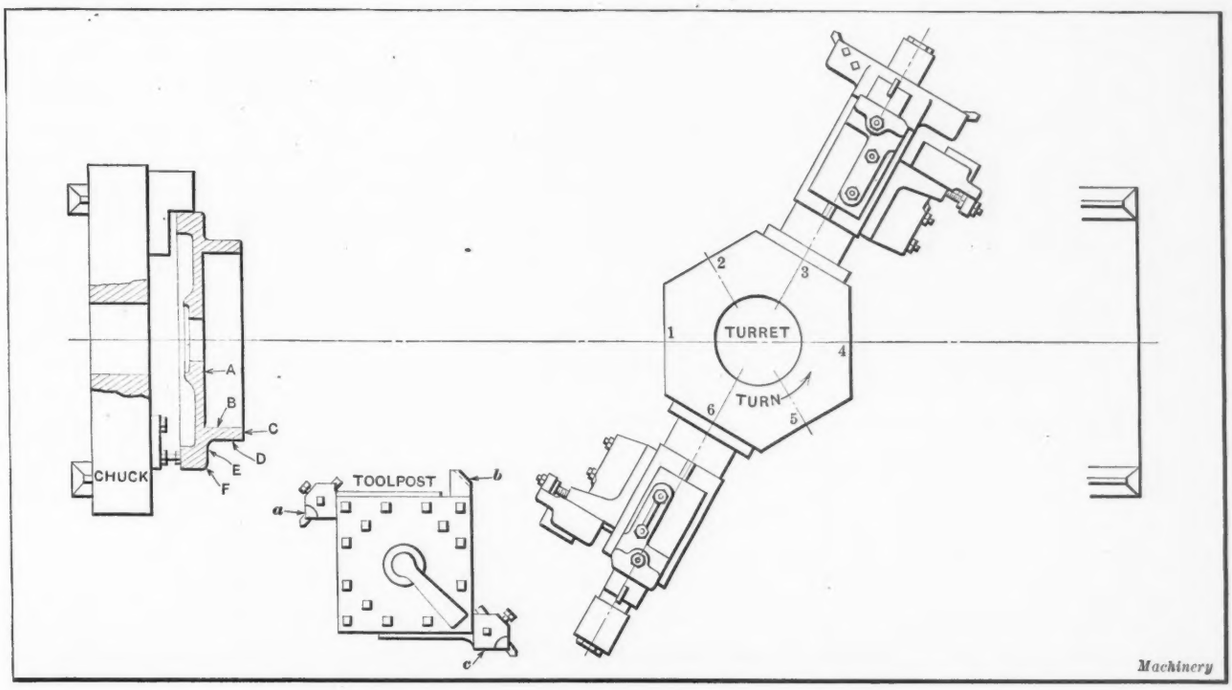

Fig. 12. Tool Lay-out for Third Operation on Automobile Flywheel

a pilot enters a bushing in the chuck, and in Operations (8) and (9) pilots enter bore *A* of the flywheel, thus insuring that outside surface *F* and bore *D* will be turned and bored true with hole *A*. The facing head mounted in Side 5 of the turret has four arms, as will be seen in Fig. 4, each of which carries one tool, the relative positions of these tools being shown diagrammatically at *N*, *O*, *P*, and *R*, Fig. 1. Cutter *N* is mounted in the top arm and finishes the surface *F*; cutter *O* is held in the rear arm and finishes *E*; cutter *P* is mounted in the front arm and finishes bore *D*; and cutter *R* is mounted in the bottom arm and finishes hub *B*. Face *E* is finally finished with tool *M* in the toolpost, face *B* being

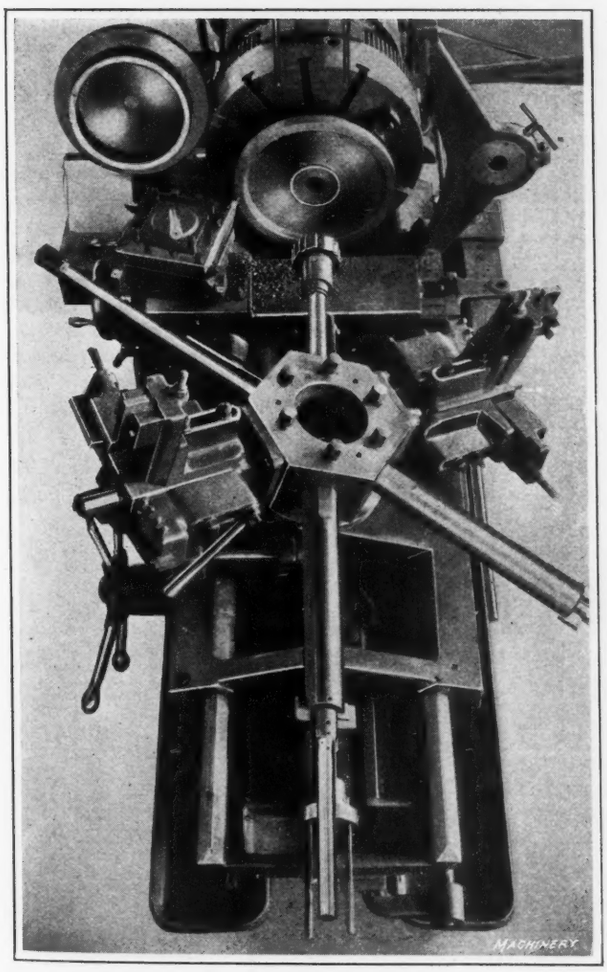

Fig. 13. Machine set up for Second Operation on Automobile Flywheel

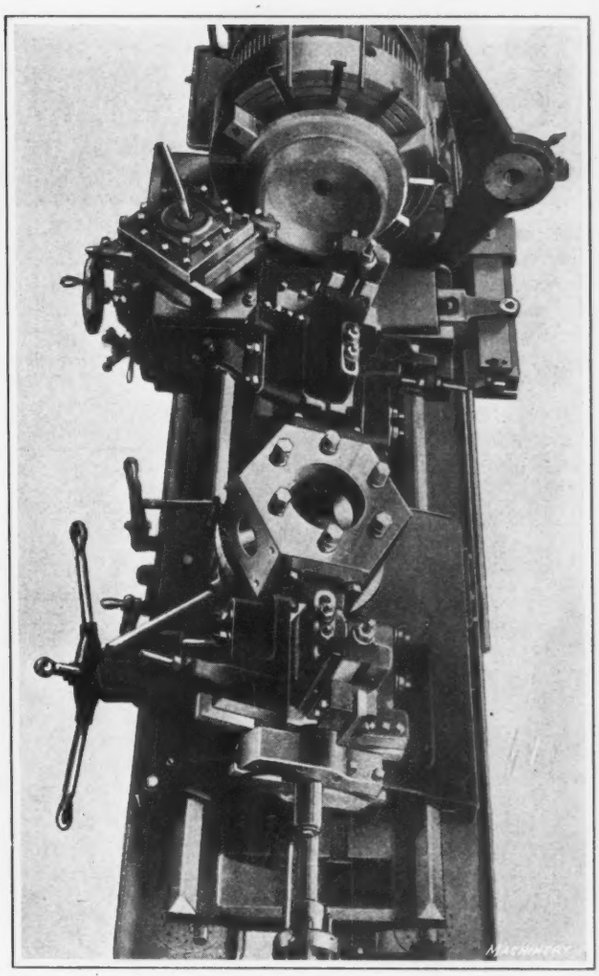

Fig. 14. Machine set up for Third Operation on Automobile Flywheel

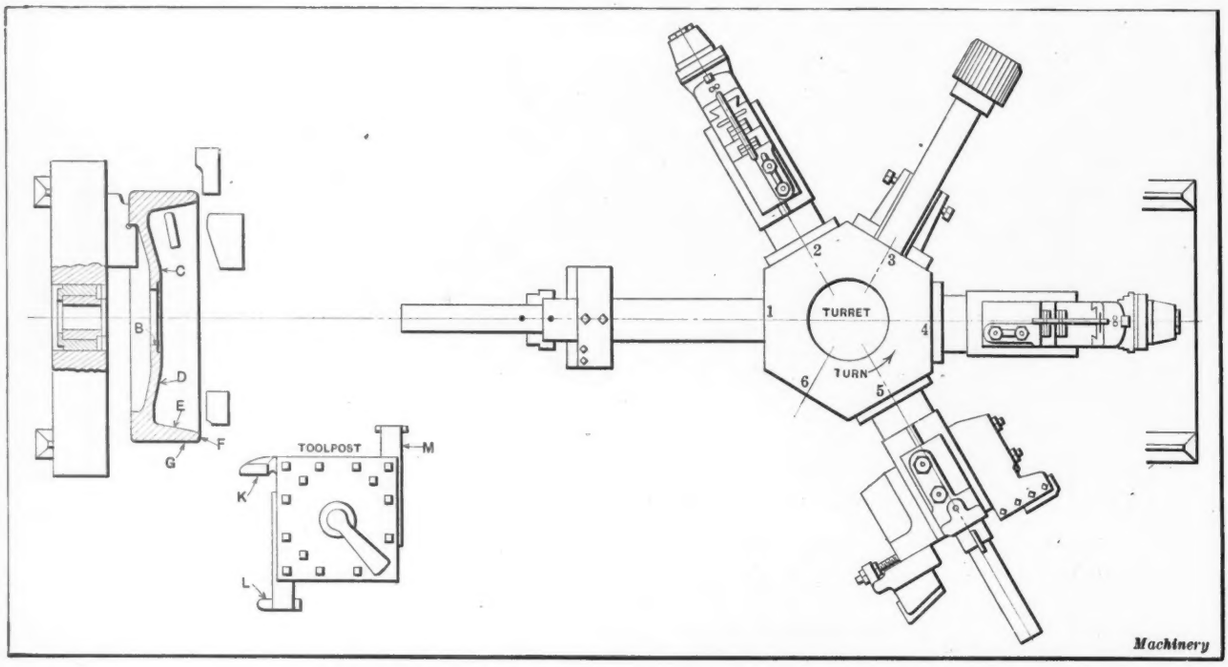

Fig. 15. Tooling Equipment for First Operation on Flywheel in Fig. 16

afterward finished by the same tool. The total time required for the first operation is 25 minutes.

In the second operation, Fig. 2, the work is finished in the following order: (1) The work is held by soft chuck jaws at *F* and supported as shown at *E*. (2) Surfaces *G* and *H* are rough-faced with tool *S* held in the toolpost. (3) Surface *J* is finished with tool *T* in the toolpost. (4) Hub *H* is faced with tool *U* in the toolpost. (5) A second roughing cut is taken on surfaces *G* and *J* and a roughing cut is also taken on surface *I* with cutters held in the facing head mounted in Side 2 of the turret. This head is provided with a pilot which enters the bore in the flywheel, thus insuring the concentricity of the cuts taken. As shown in Fig. 5, the facing head in the turret is provided with a top and a bottom arm, cutter *V*, Fig. 2, which finishes surfaces *J* and *I*, being held in the top arm, and cutter *W*, which finishes surface *G*, being held in the bottom arm. (6) Surfaces *G*, *I*, and *J* are finished with cutters held in the facing head mounted in Side 5 of the turret, this head being identical in construction with that used in the preceding step for roughing. (7) Counterbore *G* is given another finishing cut with the cutter in the head mounted in Side 1 of the turret. (8) Finally, the face of the counterbore is finished with tool *X* in the toolpost. The total time required for the second operation is 15 minutes.

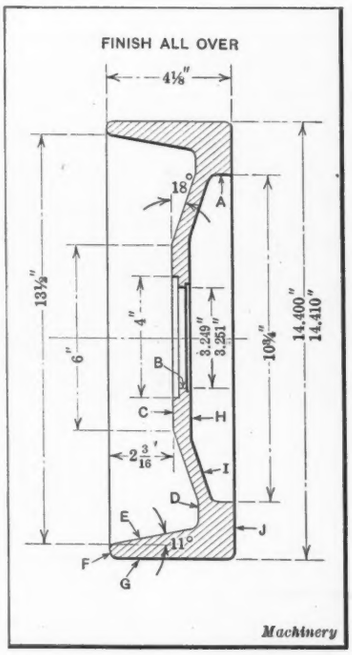

Fig. 16. Flywheel of Unusual Design

Tool Lay-out for an Automobile Flywheel Having Thin Sections

Fig. 8 shows an automobile flywheel made from semi-steel, where the sections are comparatively thin. In finishing this flywheel on the turret lathe, three operations are required instead of two, because there is a great deal of stock to be removed, and as the sections are not heavy, there would be considerable distortion if all the stock were removed at once on each side of the flywheel. In cases of this kind, one or more extra operations may be found necessary in order to overcome the difficulty caused by distortion. The first operation is simply the roughing of one side; then the other side is roughed and finished

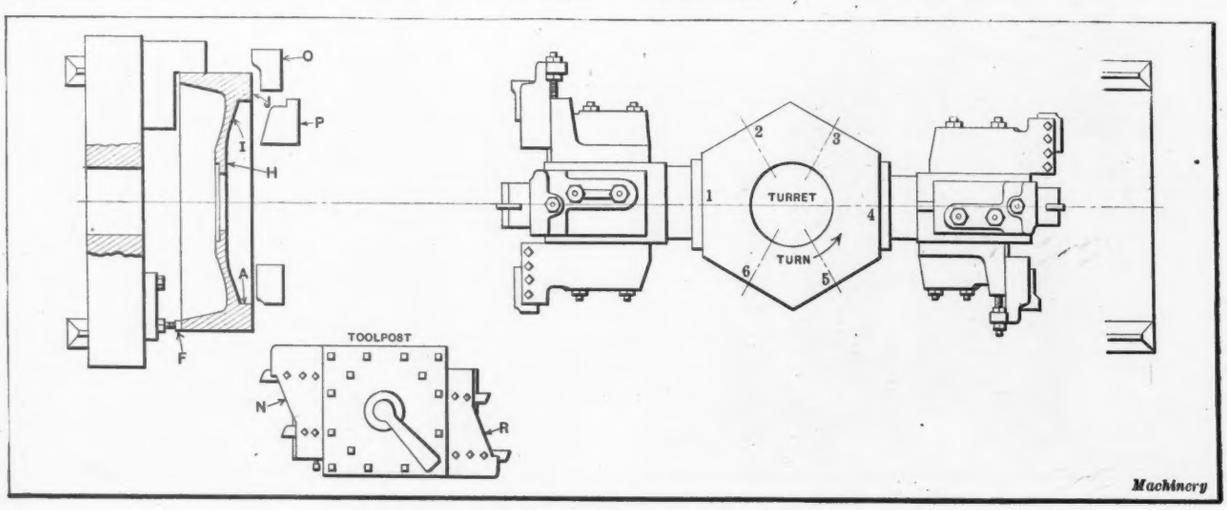

Fig. 17. Tooling Equipment for Second Operation on Flywheel in Fig. 16

in the second operation; and, finally, the flywheel is rechucked and the first side, which was roughed only, is now finished. Fig. 9 shows the tool lay-out for the first operation; Fig. 11, for the second operation; and Fig. 12, for the third operation. The rough-turned flywheel and the method by which it is held in the first operation are shown in Fig. 10. Fig. 13 shows the complete tool outfit for the second operation with the flywheel in position in the machine, while Fig. 14 shows the tooling arrangement for the third operation, this view corresponding to the line illustration, Fig. 12.

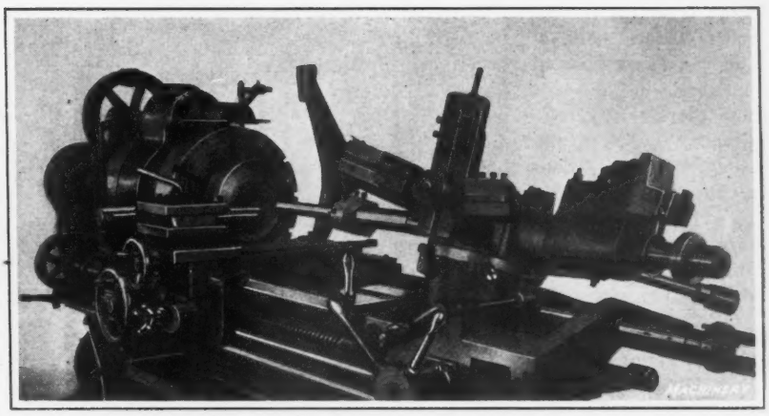

Fig. 18. Front View of Machine set up for First Operation on Flywheel in Fig. 16

The first operation, which consists in roughing one side of the flywheel, as shown in Fig. 9, is performed as follows: (1) The work is held with special hard chuck jaws, as indicated. (2) The bottom *A* is rough-faced with tool *O* in the toolpost, and the hole is bored with the cutter mounted in the bar in Side 1 of the turret. (3) The inside and outside cylindrical surfaces *B* and *D* are bored and turned, respectively, with the facing head mounted in Side 3 of the turret. The head shown mounted in Side 6 of the turret is not used, but is mounted in position simply to balance the turret. (4) Surfaces *C*, *E*, and *F* are rough-faced with tool *R* in the toolpost. The first operation is completed in 8 minutes.

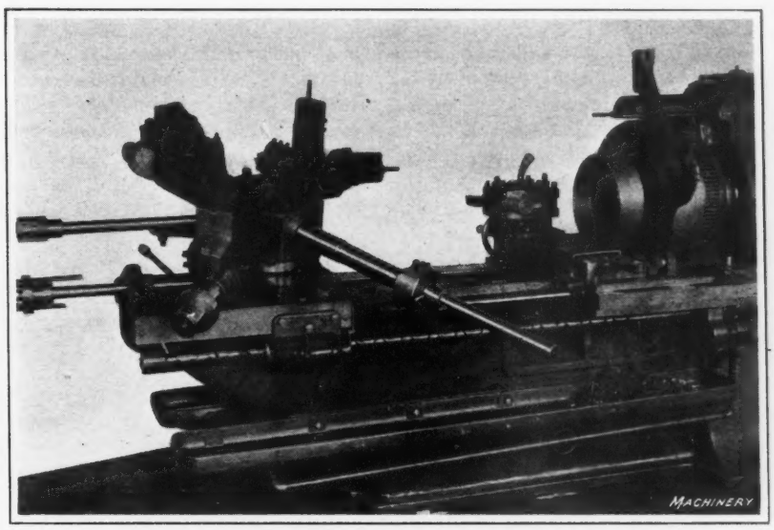

Fig. 19. Rear View of Machine set up for First Operation on Flywheel in Fig. 16

In the second operation, the work is held as shown in Fig. 11, and one side of the flywheel is both roughed and finished complete. The work is accomplished in the following order: (1) The work is held by special jaws, as indicated, and chuck jacks are used to support it against surface *A*. (2) Surfaces *H*, *I*, *J*, *K*, *L*, and the bottom of counterbore *M* are rough-faced by tool *S* in the toolpost. (3) Bore *N* and counterbore *M* are rough-bored with cutters in the bar mounted in Side 1 of the turret. (4) Bore *N* and counterbore *M* are finished with cutters in the bar mounted in Side 2 of the turret. The bars used in the last two steps are provided with pilots which enter a bushing in the chuck. (5) Bore *N* is reamed with the reamer mounted in Side 4 of the turret. (6) The outside surface *G* is rough-turned with tool *T* mounted in the toolpost, this tool being followed by the facing head mounted in Side 3 of the turret, which roughs surfaces *G*, *H*, *I*, and *L*. This facing head is provided with a pilot entering the bore of the flywheel. The tool *U*, turning surface *G*, is held in the top arm, cutter *V* is held in the front arm, cutter *W* is held in the bottom arm, and cutter *X*, in the rear arm of the facing head. (7) Surfaces *G*, *H*, *I*, and *L* are now finished by the tools held in the facing head mounted in Side 6 of the turret, the arrangement of the tools being the same as for Step (6), and the head being piloted in the bore of the flywheel in the same manner. (8) Surfaces *J* and *H* are finally finished with tool *Y* held in the toolpost. (9) The bottom of the counterbore *M* is finished by tool *Z* held in the toolpost. (10) The cylindrical surface of the counterbore *M* is finished by a reamer held in Side 5 of the turret. The total time required for the second operation is 10 minutes.

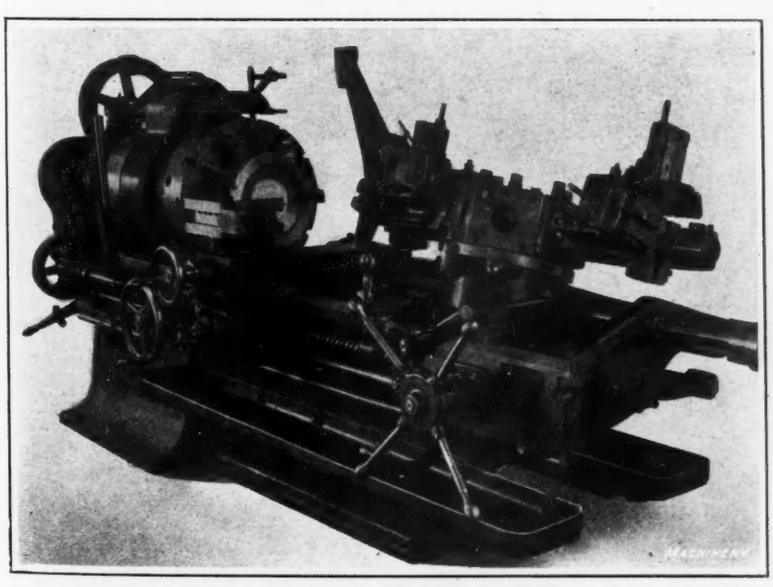

Fig. 20. Front View of Machine set up for Second Operation on Flywheel in Fig. 16

Fig. 12 shows the tooling arrangement for the third operation, which consists in finishing the side of the flywheel which was rough-machined in the first operation, the work being carried out in the following order: (1) The flywheel is held with soft jaws and supported by chuck jacks. (2) The outside of the cylindrical surface *D* and face *E* are roughed by tool *c* in the toolpost. (3) Surfaces *B* and *C* are rough-machined and surfaces *D* and *E* are finished with tools mounted in the facing head in Side 3 of the turret; this facing head is piloted in the bore of the flywheel. (4) The bottom *A* of the counterbore is finish-faced with tool *a* in the toolpost. (5) Surfaces *B*

and *C* are finished with cutters held in the facing head mounted in Side 6 of the turret. (6) The chamfer at *F* is finished with tool *b* held in the toolpost. The total time for the third operation is 10 minutes, or for all three operations, 28 minutes.

Tooling Equipment for Flywheel having an Angular Web

Fig. 16 shows a flywheel which is of unusual design in that it has a central web, part of which is at an angle with the axis of the flywheel. The material from which the wheel is made is cast iron. It is finished all over on a 24-inch Gisholt turret lathe in two operations, Fig. 15 showing the tooling equipment for the first operation, and Fig. 17, the equipment for the second operation. Fig. 18 shows a front view and Fig. 19 a rear view of the machine as set up for the first operation. Figs. 20 and 21 show front and rear views, respectively, of the machine as set up for the second operation. An additional head is shown in the photographs for counterbalance only.

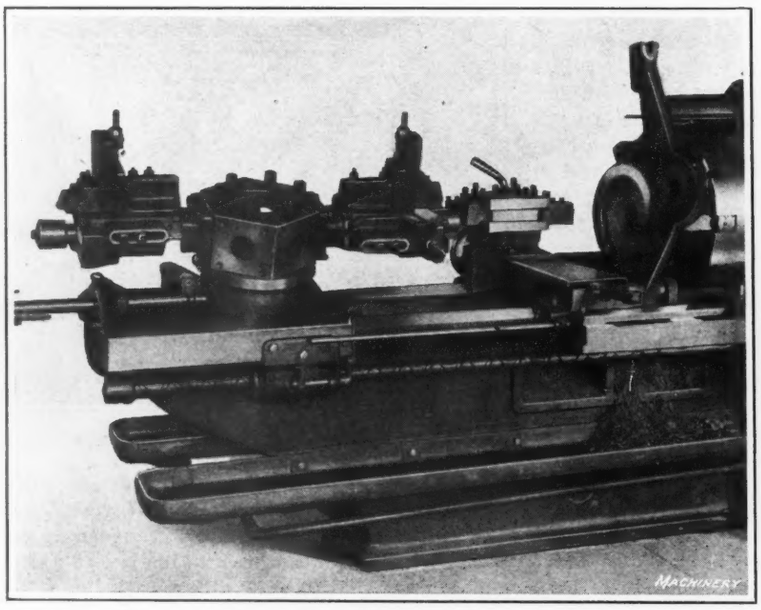

Fig. 21. Rear View of Machine set up for Second Operation on Flywheel in Fig. 16

The first operation consists of roughing and finishing the convex side of the web, the beveled inside surface, and the outside of the rim; this is accomplished as follows (see Fig. 15): (1) The work is held by the inside of the rim by special chuck jaws. (2) Surfaces *C*, *D*, and *F* are roughed with tool *K* in the toolpost. (3) The hole *B* in the flywheel is bored and the surface *C* is finish-faced with tools in the bar mounted in Side 1 of the turret. In this operation, the tool is guided by a pilot entering the bushing in the chuck. (4) Hole *B* is reamed with the reamer held in Side 3 of the turret. (5) Beveled surface *E* is rough-bored with the tool in the facing head mounted in Side 4 of the turret. Simultaneously with this operation, the outside *G* of the flywheel is rough-turned with tool *L* held in the toolpost. (6) Beveled surface *E* is finished with the tool held in the facing head mounted in Side 2 of the turret. (7) Surfaces *F* and *D* are machined and the corners of surfaces *F* are chamfered with the tools in the head mounted in Side 5 of the turret. The facing head used for this operation, more clearly shown to the right in Fig. 18, is especially designed for finishing the tapered surface *E* with a single-point tool, thus insuring the correct angle. A pilot enters the bore of the flywheel, and a flange is provided with a ball thrust bearing which bears against the web of the wheel at *C*, thereby accurately locating the tool and preventing the pilot from entering beyond a certain point. The head then slides over the pilot, and as the head is provided with a pin which rests against a tapered surface immediately beyond the thrust bearing shown in Fig. 18, the tool in the facing head is lowered as it slides forward and the tool mounted in the facing head will finish the tapered surface accurately. (8) Finally, the outside *G* of the flywheel is finished with tool *M* held in the toolpost.

The second operation, shown in Fig. 17, consists in roughing and finishing the concave side of the flywheel. The step-by-step method of performing the work is as follows: (1)

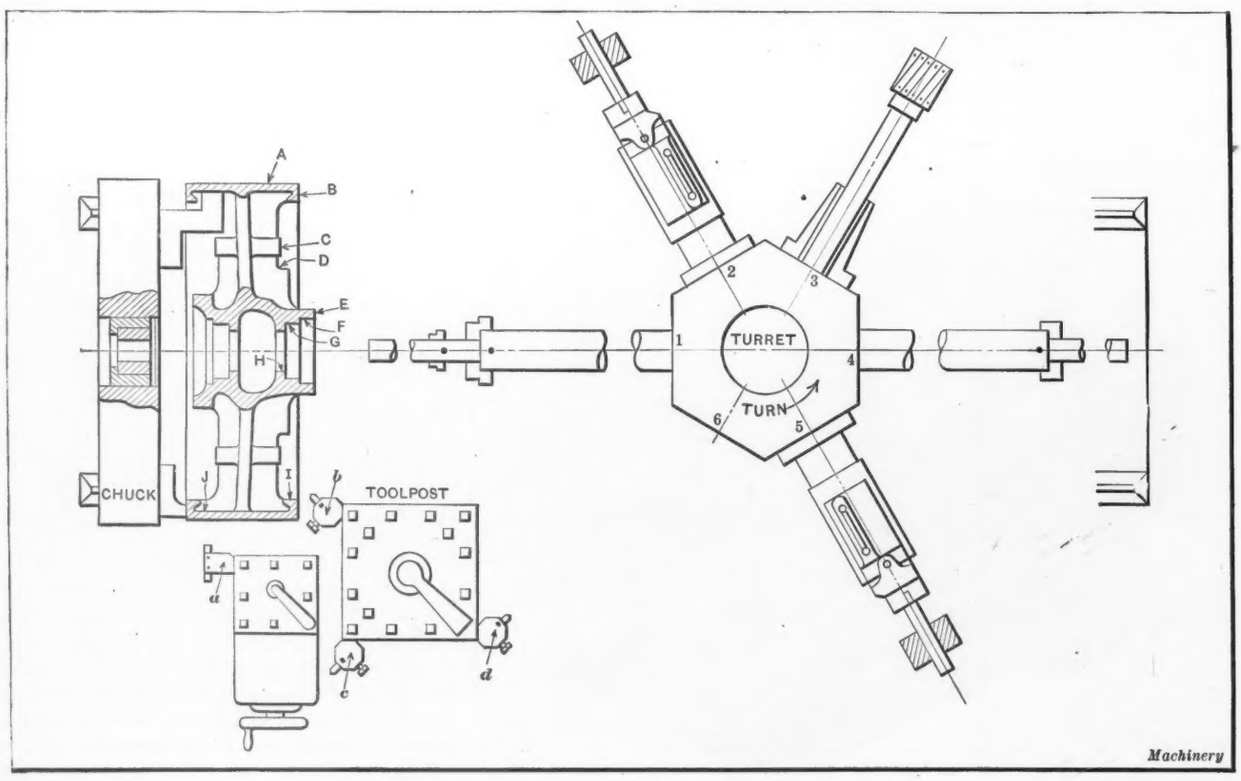

Fig. 22. Tool Lay-out for First Operation on Truck Wheel in Fig. 24

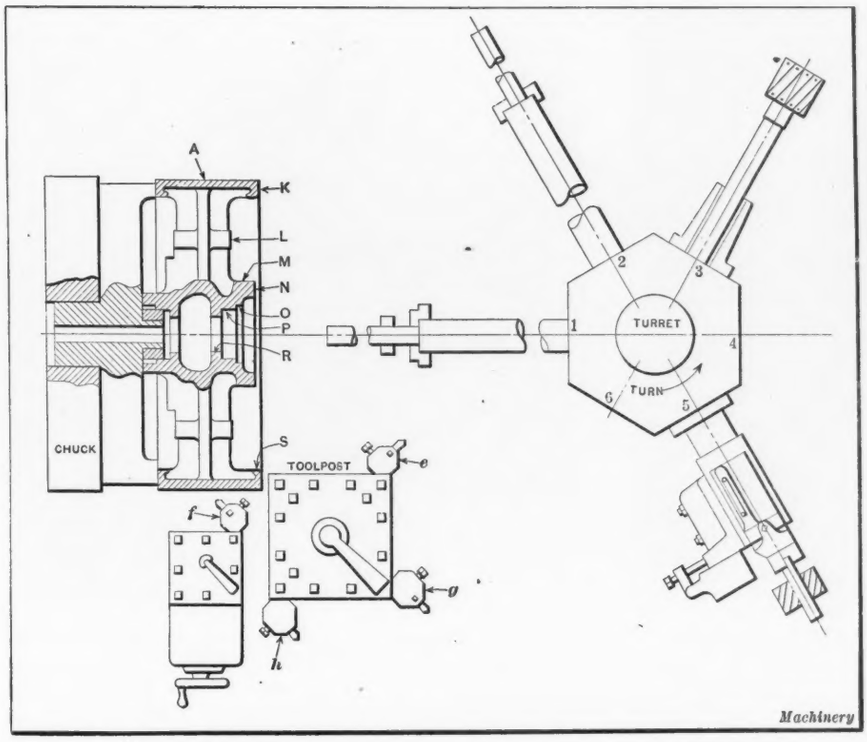

Fig. 23. Tooling Equipment for Second Operation on Truck Wheel illustrated in Fig. 24

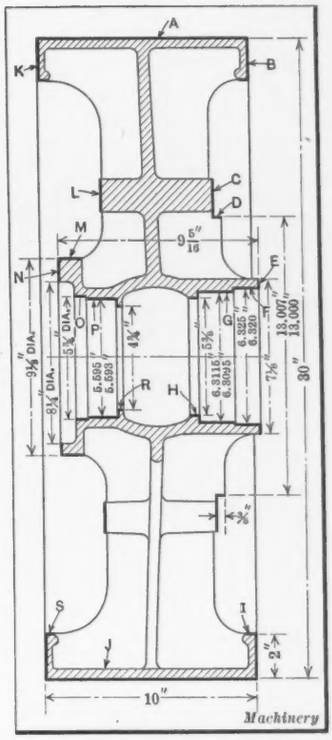

Fig. 24. Truck Wheel finished in Two Operations

The work is held with soft jaws bearing against the finished outside of the flywheel and supported with chuck jacks bearing against the rim at *F*. (2) Surfaces *H*, *I*, and *J* are rough-faced with tools held at *N* in the toolpost. (3) Surface *A* is rough-bored and surface *I* is rough-faced, and the outside corner at *A* rounded with tools held in the facing head mounted in Side 1 of the turret. (4) Surfaces *A* and *I* are finished and the inside corner at *A* is rounded with tools held in the facing head mounted in Side 4 of the turret. In both Steps (3) and (4) the facing head is piloted in the bore of the flywheel, and tool *O* is held in the rear arm, while tool *P* is held in the top arm. (5) Surfaces *H* and *J* are finished with tools held at *R* in the toolpost.

Tooling Equipment for Auto Truck Wheels

Fig. 24 shows the design of a rear wheel for an automobile truck. The heavy lines indicate the surfaces that are finished in the turret lathe. This example of turret lathe practice is of especial interest in that the complete tooling equipment that can be arranged for on the turret lathe is brought into action, including the auxiliary toolpost, also known as the "wing-rest" toolpost, which is best shown in Fig. 25 where it is being operated as indicated. All the Gisholt turret lathes have an extension on the carriage for this auxiliary toolpost so that it may be used, if required, for turning diameters which are too large for the regular toolpost. At the same time, this auxiliary toolpost provides for an addition to the number of permanently set tools that may be used. The auxiliary toolpost is also well illustrated in Fig. 29. The percentage of turret lathe jobs where the auxiliary toolpost is required is small, it seldom being necessary to use it, either on account of the size of the work or because all the tooling facilities on the machine are employed, as in the present case.

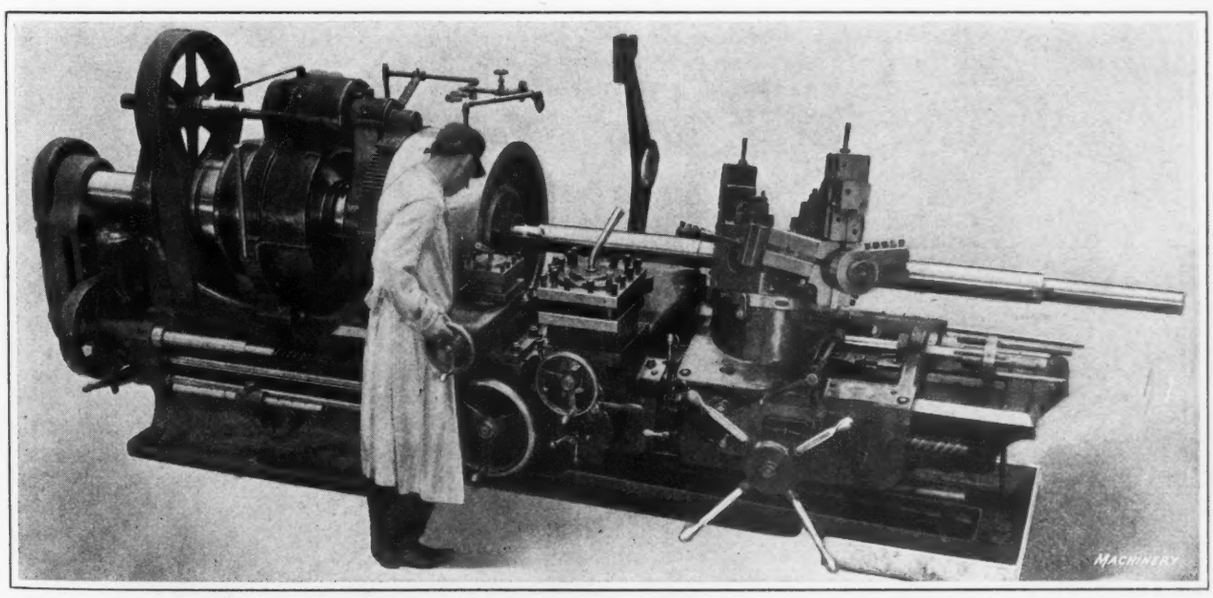

Fig. 25. Front View of Machine set up for First Operation on Truck Wheel

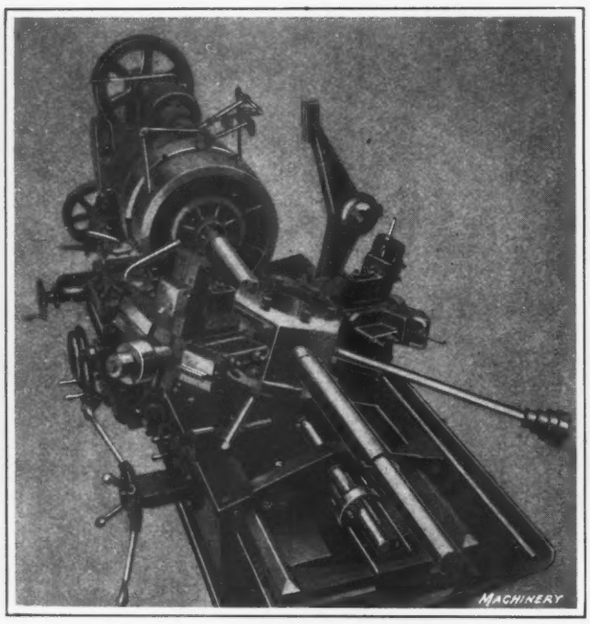

Fig. 26. Top View showing Tooling Equipment of Machine set up for First Operation on Truck Wheel

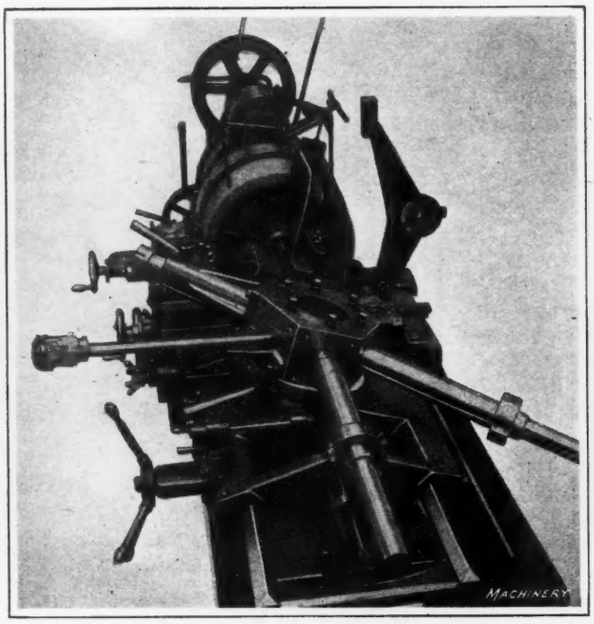

Fig. 27. Top View showing Tooling Equipment of Machine set up for Second Operation on Truck Wheel

The truck wheel is finished in two operations, the lay-out for the first operation being shown in Fig. 22, and for the second operation, in Fig. 23. The halftone illustrations, Figs. 25, 26, and 29 show different views of the first operation, while Figs. 27, 28, and 30 show views pertaining to the second operation. Fig. 25, as mentioned, shows the auxiliary toolpost in operation and a general view of the machine set-up. Fig. 26 gives a better view of the tooling equipment, as it shows the machine from the top, while Fig. 29, being a detail view, shows more clearly the work in place on the machine. The halftone illustrations showing the second operation are arranged in the same manner, with a general view (Fig. 28), a top view showing the tools in the turret (Fig. 27), and a detail view showing the work in place on the machine on a larger scale (Fig. 30). The material from which the truck wheels are made is cast steel.

The step-by-step method for the first operation, Fig. 22, is as follows: (1) The wheel is held from the inside of the rim by means of special hard jaws at *J*, and is located by special blocks on the chuck. (2) The outside *A* of the wheel is rough-turned with tool *a* held in the auxiliary toolpost or wing-rest. (3) Surfaces *B*, *C*, *D*, and *E* are rough-faced with tool *b* in the toolpost. (4) Holes *F*, *G*, and *H* are bored with cutters held in the boring-bar mounted in Side 1 of the turret. This bar is provided with a pilot guided by a bushing in the chuck of the machine. (5) Surface *G* is finish-bored with a cutter held in the bar mounted in Side 4 of the turret, this bar being guided in the same manner as the roughing bar. (6) Hole *G* is reamed with a reamer mounted in Side 3 of the turret. (7) Surfaces *D* and *E* are rough-turned with cutters held in the facing head mounted in Side 2 of the turret, the tool operating upon surface *D* being held in the top arm and the tool operating upon surface *E*, in the bottom arm of the facing head. (8) Surfaces *D* and *E* are finished with tools held in the facing head mounted in Side 5 of the turret. This facing head and the tooling arrangement is identical with that used for the roughing operation on the same surfaces. (9) Surfaces *B* and *C* are finished with the tool *c* held in the toolpost. (10) The inside of the rim at *I* is bored with tool *d* in the toolpost. The total time required for the various steps in the first operation is 50 minutes.

The second operation, Fig. 23, also makes use of the auxiliary toolpost or wing-rest, the various steps being as follows: (1) The work is held on a special chuck plate by

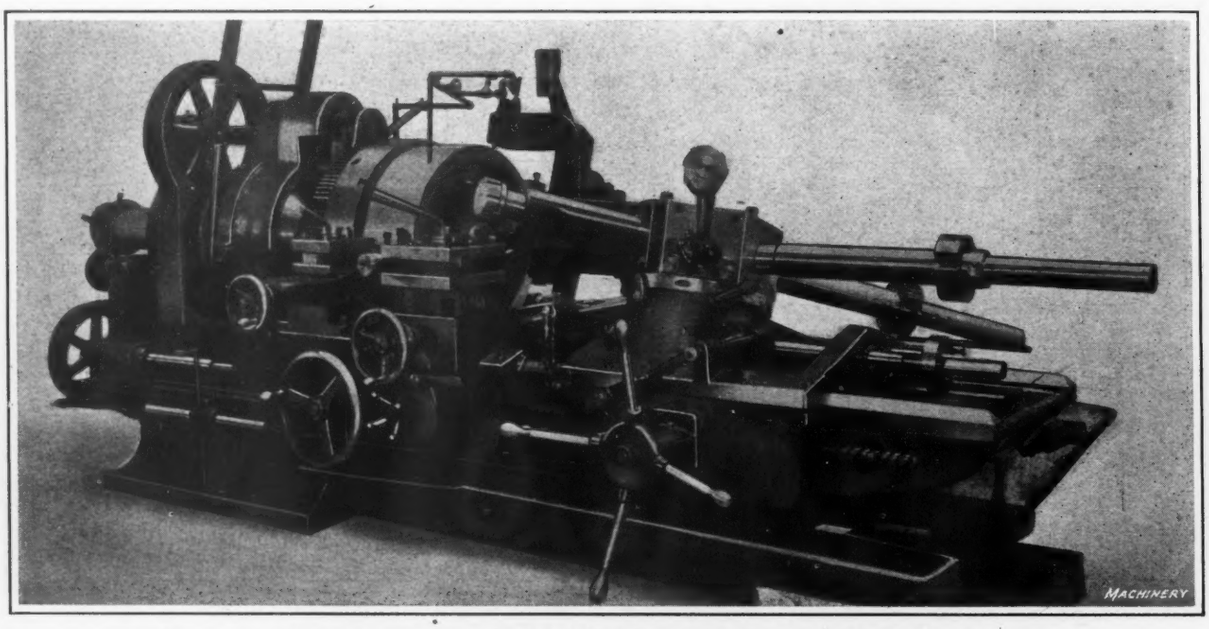

Fig. 28. Front View of Machine set up for Second Operation on Truck Wheel

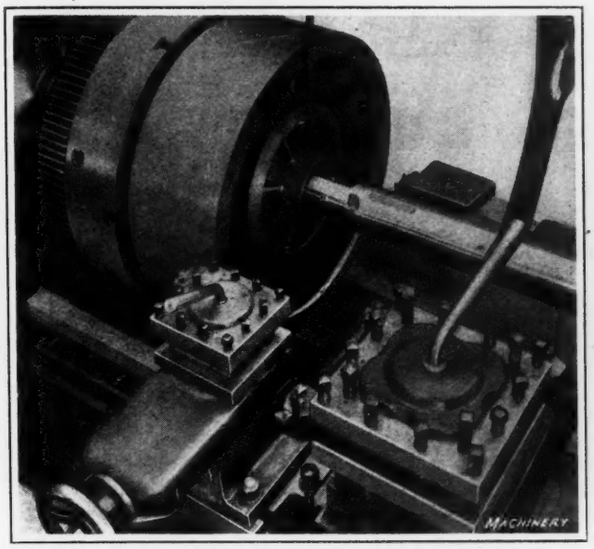

Fig. 29. Detail View of First Operation on Truck Wheel

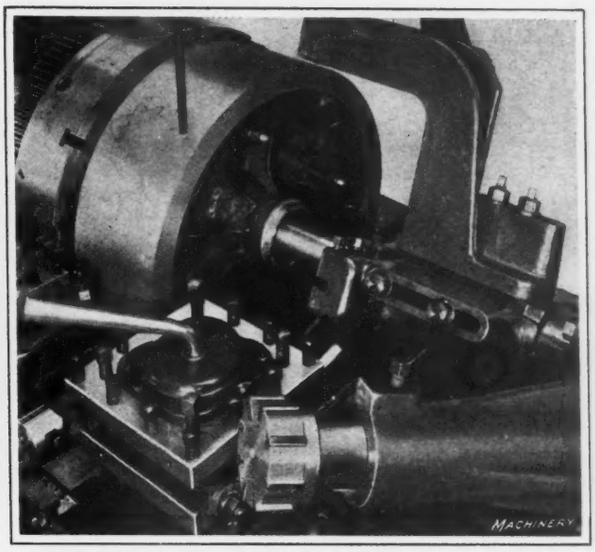

Fig. 30. Detail View of Second Operation on Truck Wheel

clamps. (2) Surfaces *K*, *L*, *M*, and *N* are rough-machined with tool *e* held in the toolpost. (3) Holes *O*, *P*, and *R* are rough-bored with cutters held in the boring-bar mounted in Side 1 of the turret. This bar has a pilot which is guided in a bushing mounted in the chuck plate. (4) Hole *P* is finish-bored with a cutter held in the boring-bar mounted in Side 2 of the turret, this bar being piloted in the same manner as that used for the roughing cut. (5) Hole *P* is reamed with a reamer mounted in Side 3 of the turret. (6) A second roughing cut is taken on the outside *A* of the wheel with the tool held in the auxiliary toolpost or wing-rest, this cut being followed by the advance of the facing head mounted in Side 5 of the turret, which finishes the outside of the rim *A* and also the surfaces *M* and *N*, the three tools required being mounted in the top arm, rear arm, and the bottom arm of the head, respectively. While this operation takes place, the facing head is guided by a bushing on its pilot which enters into hole *P*. (7) Surfaces *K* and *L* are finished with tool *g* in the toolpost. (8) The inside of the rim at *S* is bored with tool *h* in the toolpost. The total time required for the second operation is 45 minutes.

An interesting feature in connection with the work just described is that the truck wheels shown in Fig. 31, while differing considerably in design from that shown in Fig. 24, were finished with practically the same tooling equipment as that used for the truck wheel in Fig. 24, except that different sizes of cutting tools, boring-bars, and reamers were used to suit the different sizes of holes and counterbores required. Each of these truck wheels is finished in two operations, the same as that shown in Fig. 24, and the step-by-step methods in each case are quite similar, so that it is not necessary to repeat the complete procedure. It may be of interest to note, however, that the front wheel shown at *A*, Fig. 31, is finished complete in 47 minutes, the first operation requiring 25 minutes, and the second, 22 minutes. The rear wheel shown at *B* requires a total time of 55 minutes, the first operation taking 33 minutes and the second, 22 minutes. The front wheel shown at *C*, Fig. 31, is finished in 65 minutes, the first operation requiring 32 minutes and the second operation requiring 33 minutes.

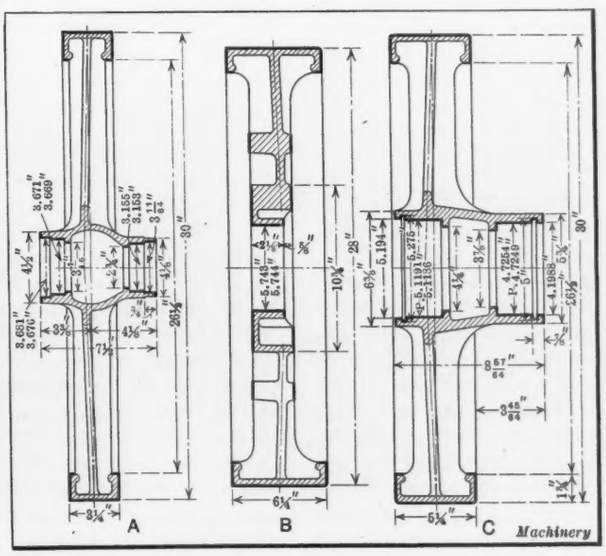

Fig. 31. Truck Wheels finished by practically the Same Tooling Equipment as shown in Figs. 22 to 30, Inclusive

The following articles in this series will deal with the machining of cylinders, piston ring castings, tractor axle housings, motor frames, clutch drums, valves, etc., and in addition there will be an article dealing with the system and methods of the service department of the Gisholt Machine Co., by which the customer's needs are studied so that he may not only buy machines and tools, but will also be assured of actual production on those machines and tools in his own plant.

* * *

AIR MAIL SERVICE RECORD

It is stated in the *Journal of the Society of Automotive Engineers* that a record of 99 per cent was made by the Air Mail Service between Washington and New York for the month of June. The total mileage covered was 11,118, and the total weight of mail carried 15,643 pounds. On the Cleveland-Chicago division, a perfect score of 100 per cent was obtained. In this division, the total mileage was 19,825 miles, and the weight of the mail carried 19,603 pounds. The average speed on that route for the month was 97.8 miles per hour. The operation of the Cleveland-Chicago route is without parallel in the history of aviation. Since May 15, seventy consecutive daily non-stop flights of 325 miles each were made without a forced landing. On the next trip a gas-line connection sprung a leak, causing a forced landing on the Emergency Air Mail Landing Field at Bryan, Ohio. The route from New York to Cleveland, across the Allegheny Mountains, has been operating with the same degree of perfection as the Cleveland-Chicago route since July 1.

* * *

Much interest is being shown in China in motorcycles, due to the fact that they can travel on the paths used by foot passengers, as there are but few roads suitable for automobiles. If these paths were improved, commercial travelers could penetrate with ease, by the use of motorcycles, to places which are now practically inaccessible.

Design and Calculation of Williams Internal Gearing

By REGINALD TRAUTSCHOLD

A new system of internal gearing has been devised by Harvey D. Williams, a man recognized as a gear designer of considerable ability and knowledge. Mr. Williams was formerly professor of kinematics at Cornell University and subsequently entered the Government service. In this capacity he designed a great number of special gears and he is also the inventor of a new type of bevel gear. His internal gear, with which the present article deals, is now being introduced to the public, although Mr. Williams has himself employed the construction for some years past. A water wheel driving a motor for lighting and power purposes has been equipped with a Williams large internal gear for the past four or five years and the transmission has proved unusually efficient. The gearing shows practically no sign of wear despite the fact that it has run continually since its installation. At the present time a number of important users of internal gears are considering adopting this system, and prominent gear manufacturers are showing considerable interest in the development. But, so far, little publicity has been given to the system, and what publicity there has been has dealt with general principles only. The present article is the first one that deals with the design in detail, showing working formulas and complete lay-outs necessary for proper design and will, therefore, prove of great interest.

THE Williams system of internal gearing possesses those elements of simplicity and low cost of manufacture which distinguish the Williams system of bevel gearing, and decided mechanical efficiencies are realized by virtue of the simpler construction. In the new system, the profiles of the internal gear teeth are straight lines, so that the tooth spaces are similar to those of an involute rack, while the teeth of the mating pinion have curved profiles of conjugate form. This radical departure from the involute and other systems of gearing secures a number of inherent advantages for the new system which give a much longer arc of tooth contact, improve the operating action, reduce wear, and increase the strength of the pinion teeth. Gear combinations in which the pinion has considerably fewer teeth than are feasible in the involute system of internal gearing are practicable with Williams gearing, and the compactness thus attainable makes possible higher speed ratios for simple combinations without the diameter of the internal gear exceeding practical dimensions.

All the advantages possessed by the internal form of gearing are not only retained in the Williams construction, but in nearly every instance are materially accentuated. Not only are production costs much less, but also the accuracy with which the teeth may be finished to approved profile is far greater than in the involute system. No modification of tooth profiles is necessary, such as is so generally resorted to for the greater part of the depth of teeth of involute form, particularly in the case of internal gears.

Lay-out of Williams Internal Gears

The distinctive form of the Williams internal gear teeth is well illustrated in the diagrammatic lay-out shown in Fig. 2. The profile planes of the gear teeth are all tangent to a circle concentric with the gear, the radius L of which is equal to the pitch radius of the internal gear multiplied by the sine of the sum of one-half the tooth space angle c and one-fourth the pitch angle. The path of point of contact—the distinguishing feature of the system—lies in a curve passing through the instant axis m of the meshing gears. The section of this curve which constitutes the maximum or usable path of point of contact (that is, arc st) may be considered as the arc of a circle having its center S half way between the instant axis and the foot of a normal radiant of the circle of profile plane tangency.

The longest possible path of point of contact is from s to t, these being points at the intersection of radiant lines of the describing circle of the path of point of contact. Point s, at the approach end lies in a radiant line passing through the center of the describing circle and the center of the mating pinion, while point t at the recession end lies in a straight line passing through the center of the describing circle and that of the internal gear. These points connected by radiant lines to the center of the pinion and of the internal gear, fix the usable angles of contact for the pinion and for the gear. The usable angle of approach u for the pinion is apparently much greater than could be secured for an involute gear of the same size and pressure angle. Similarly, the usable angle of approach U for the internal gear is greater than could be secured for an involute gear of the same size and pressure angle.

The angles of recession for Williams gears are finite, it is true, while in the involute system they are theoretically infinite. However, in the involute system very definite limitations are placed on the lengths of the arc of recession by the practical limits to the flank depth of the internal gear and the addendum of the pinion teeth. These limitations make the usable recession angles (v in the Williams pinion, and V for the internal gear) appreciably greater than in the involute system.

Arcs of Contact

The entire arc of contact, particularly the recession section, is rarely made use of in the Williams system, but such arc of contact as is employed is invariably greater than that for corresponding internal gear combinations proportioned according to the involute system—that is, greater than when the angularity of the contact planes of the teeth is the same. In many instances this is so, even if the pressure angle for the involute teeth is much greater than that for the Williams teeth. In the involute system, the length of the arc of contact that is possible with the Williams system may be secured only by materially increasing the pressure angle and adopting the stub form of tooth. This modification, now so generally resorted to for commercial gear combinations, has the decided disadvantage of reducing the mechanical efficiency of the transmission by increasing the axial component of the transmitted force, thereby decreasing the effective component.

The large diagram in Fig. 1 illustrates the Williams gear combination shown in Fig. 2. Contact between meshing

teeth commences at the point p, the intersection of the inner circle of the gear with the path of point of contact, and ends at the point r, the intersection of the outer circle of the pinion with the path of point of contact, so the actual arc of pinion contact is measured by the angle g. This angle, it will be noted, is much smaller than the usable angle of contact w.

The derivation of the simple equation for the actual angle of approach e entails the solution of the triangle pSO, while evolving an equation for the actual angle of recession f, requires the solution of the triangle rSo. These two triangles are duplicated at reduced scales in the lower left- and right-hand corners, respectively, of the illustration. The sum of these two angles measures the actual arc of contact

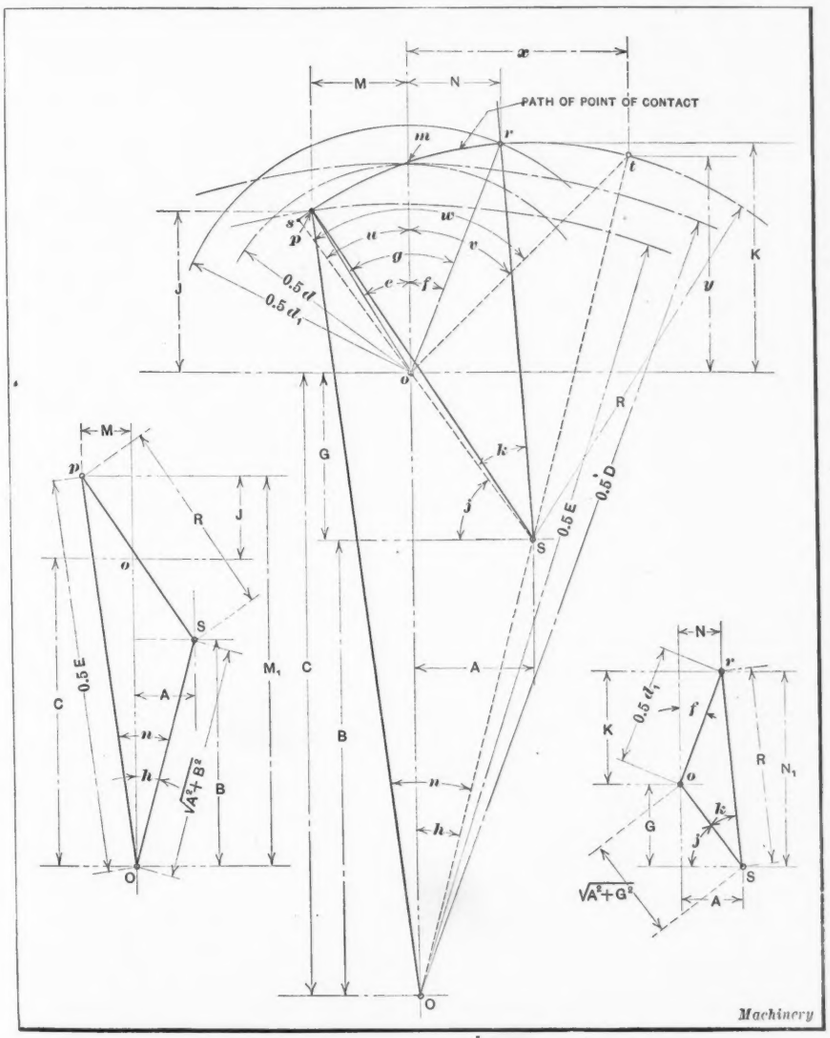

Fig. 1. Diagrams used in Williams System of Gear Formula Calculations

for the pinion in a combination of Williams gears.

The diagram shown in Fig. 3 depicts an internal gear combination of involute form, the path of point of contact of which is a straight line passing through the instant axis and normal to the advancing profile of the pinion tooth at the moment the pitch line of the pinion is at the instant axis. The commencement of contact occurs at p_1, the foot of the radial which is normal to the path of point of contact; the termination of contact occurs at the point r_1, the intersection of the outer circle of the pinion with the path of point of contact. The angle of approach e_1, which is the maximum for the involute form of tooth with the pressure angle shown, is no greater than the pressure angle of the teeth will allow, while the angle of recession f_1 also appears quite limited.

The angle of recession can be increased by increasing the inner diameter of the gear and adopting the stub form of gear tooth. This modification can be carried to such a point, without sacrifice of angle of approach, that the diameter E of the internal gear becomes equal to F. Sacrifices result, however, in a certain reduction in the recession angle, due to the increased pressure angle, and a reduction in the effectiveness of power transmission, due to the increase in the axial thrust incidental to the use of the heavier pressure angle. It can readily be seen that the departure from the involute tooth of standard proportions entails weaknesses which are compensated for only in part by the increased strength of the teeth and the reduction in seriousness of tooth interference.

In the Williams system of internal gearing, on the other hand, an increase in the obliquity of the profile planes of the teeth is seldom called for, since interference is largely avoided by the design, and a stub tooth is rarely necessary. The angle of approach and the recession angle, are usually considerably larger in the Williams construction than in equivalent involute gear combinations.

Comparison of Arcs of Contact of Williams and Involute Internal Gearing

A comparison of the respective arcs of contact for the two systems of gearing, by a concrete example, will emphasize the superiority of the Williams construction; but for the comparison to be convincing, a gear combination should be selected of proved suitability to the involute system of internal gearing. A combination of a 20-tooth internal gear and a 12-tooth pinion is one frequently employed, and when such involute gears have 20-degree stub teeth the pinion is free from any marked under-cutting.

Though the stub tooth is adopted in the involute system to secure adequate tooth strength and to avoid interference, a tooth of less obliquity may be used in the Williams system without reducing the height. In this system, as the path of the point of contact is a curve, the angularity of the direction of pressure, in reference to the plane of tangency at the instant axis, varies throughout the path of point of contact, being greater during approach and less during recession than it is at the instant axis. If a logical comparison of the two systems is to be made some common obliquity of teeth must be selected.

Since the profiles of involute gear and pinion teeth are tangent when in full mesh, and since the flat profiles of the Williams internal gear teeth are likewise tangent to the profiles of the mating pinion teeth when they are in full mesh, the inclination of the flat gear tooth profiles relative to the center line of the tooth space is comparable to the pressure angle of the involute teeth. In the Williams system, when the line of contact between meshing teeth is at the instant axis, the direction of pressure is inclined to the common tangent plane of the gear and pinion at an angle a, equal to the sum of one-half the tooth space angle and one-fourth the pitch angle of the gear. This angle, which may be termed the "instant pressure angle," will, of course, vary with the number of teeth in the gear regardless of the tooth space angle. The instant pressure angle for a 20 to 12 Williams internal gear combination with a 29-degree tooth space angle is 19 degrees, while for a 40 to 12 combination with the same tooth space angle the instant pressure angle is 16¾ degrees. The instant pressure angle will always be greater than half the tooth space angle.

The actual angle of approach for a 20 to 12 Williams gear

combination, with a tooth space angle of 29 degrees and teeth of standard depth, is 21 degrees, 18 minutes, and the angle of recession (both measured by the pinion) is 24 degrees, 45 minutes; or the actual angle of contact as measured by the pinion is 46 degrees, 3 minutes. (See accompanying example for computations). A 20 to 12 combination of involute gears would necessitate a 20-degree pressure angle and a 4/5 pitch; the angle of approach, in such case, would be 20 degrees, and the angle of recession would be 14 degrees, making a total angle of contact, measured by the pinion, of 34 degrees. (See accompanying example for computations).

As far as the length of arc of contact is concerned, the superiority of the Williams gearing (which, for convenience, may be termed a 14½-degree combination) is thus seen to be about 36 per cent. If the inclination of the Williams gear teeth profiles, in this particular combination, is increased, making the tooth space angle 40 degrees—a 20-degree combination—and at the same time, if the depth of tooth remains constant, the angle of contact, as measured by the pinion, is about 44½ degrees instead of 46 degrees, 3 minutes. This reduction is due to the fact that a smaller proportion of the usable path of point of contact is capable of being employed, owing to the limitations established by the depth of the pinion teeth. Such limitations would be more marked if the stub tooth were employed, so that the length of the arc of contact for a 20 to 12, 4/5-pitch Williams 20-degree combination would become about the same as that of the stub tooth involute gear combination. However, as the best combination of the respective systems should logically be employed, the relative merits of the two systems in respect to arc of contact for the particular combination may be taken as favoring the Williams construction at a ratio of about 136 to 100. Such superiority becomes greater as the speed ratio of the internal gearing increases, if the gears are suitably proportioned as to pitch, etc.

Definitions of Notation Used in Equations and Formulas (Williams System)

a = instant pressure angle (gear)
b = ¼ pitch angle (gear)
c = ½ tooth space angle (gear)
d = pitch diameter (pinion)
d_1 = outer diameter (pinion)
e = actual approach angle (pinion)
f = actual recession angle (pinion)
g = actual contact angle (pinion)
h = angular offset of generating circle
j = angularity from center of generating circle to center of pinion
k = construction angle
m = instant axis
n = construction angle
o = pinion center
p = commencement of tooth contact
r = end of tooth contact
s = commencement of usable path of point of contact
t = termination of usable path of point of contact
u = usable approach angle (pinion)
v = usable recession angle (pinion)
w = usable contact angle (pinion)
x, y = coordinates of usable path of point of contact about pinion center
A = abscissa of center of generating circle
B = ordinate of center of generating circle
C = center distance
D = pitch diameter (gear)
G = difference between ordinate of center of generating circle and the center distance
J = ordinate of commencement of tooth contact (pinion)
K = ordinate of termination of tooth contact (pinion)
L = radius of circle of profile plane tangency
M = abscissa of point of first contact
M_1 = ordinate of point of first contact
N = abscissa of point of last contact
N_1 = ordinate of point of last contact
O = gear center
R = radius of generating circle
S = center of generating circle
T = number of teeth (gear)
U = usable approach angle (gear)
V = usable recession angle (gear)
W = usable contact angle (gear)

Definitions of Notation Used in Equations and Formulas (Involute System)

a_1 = pressure angle (gear and pinion)
d = pitch diameter (pinion)
d_1 = outer diameter (pinion)
e_1 = usable approach angle (pinion)
f_1 = actual recession angle (pinion)
g_1 = actual contact angle (pinion)
l = angle between path of point of contact and limiting pinion radius of recession angle
m = instant axis
o = pinion center
p_1 = commencement of tooth contact
r_1 = end of tooth contact
C = center distance
D = pitch diameter (gear)
E = inner diameter (gear)
F = limiting inner gear dia.
O = gear center

Equations and Formulas for Williams Gear System (Figs. 1 and 2)

$$b = \frac{90 \text{ degrees}}{T}$$

$$a = b + c$$

$$L = 0.5D \sin a$$

$$R = 0.25D \cos a \quad (1)$$

$$A = R \sin a \quad (2)$$

$$B = 0.5D - R \cos a \quad (3)$$

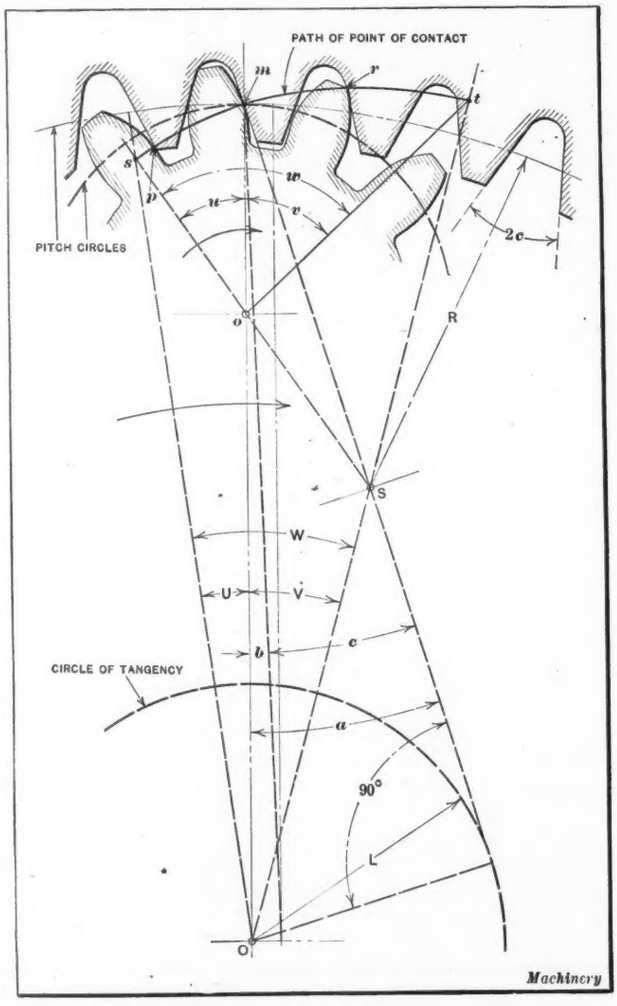

Fig. 2. Diagrammatic Lay-out of Williams Internal Gearing

$$\tan h = \frac{A}{B} \quad (4)$$

$$\cos n = \frac{A^2 + B^2 + 0.25E^2 - R^2}{E\sqrt{A^2 + B^2}} \quad (5)$$

$$M = 0.5E \sin (n - h) \quad (6)$$

$$M_1 = 0.5E \cos (n - h) \quad (7)$$

$$J = M_1 - C \quad (8)$$

$$\tan e = \frac{M}{J} \quad (9)$$

$$\tan j = \frac{G}{A} \quad (10)$$

$$\cos k = \frac{R^2 + A^2 + G^2 - 0.25d_1^2}{2R\sqrt{A^2 + G^2}} \quad (11)$$

Some complications arise in evolving a suitable equation for the recession angle f of the arc of contact in the Williams system. This is due to two facts: First, the ordinate B of the center of the generating circle in reference to the axial plane of the internal gear which is normal to the common axes plane of the gear and pinion, may be greater or less than the center distance of the gears, so that when C is greater than B

$$K = N_1 - G$$

and when B is greater than C

$$K = N_1 + G$$

The second factor which causes complications in deriving the equations for the angle of recession is that the distance N from the point of termination of tooth contact to the common axes plane may either equal, be greater than or less than the distance A from the center of the generating circle to the common axes plane. If either the sum of angles j and k or their difference is equal to 90 degrees, then

$$N = A$$

and

$$N_1 = R \pm G$$

The distance N may be sufficiently greater than distance A to employ the full usable section of the recession path of point of contact. From the foregoing it will be apparent that there are six sets of equations necessary for determining the rectangular coordinates N and N_1 of the point of tooth contact termination about the center of the pinion, in order to take care of all possible conditions. When the conditions of the problem are governed by any of the first five cases, the following equation applies for the recession angle.

$$\tan f = \frac{N}{K}$$

while the equation employed when the conditions of the problem are satisfied by the sixth case is:

$$\tan f = \frac{x}{y - C}$$

The selection of the suitable set of equations (or case) for any given conditions is definitely set by plainly established limits. In measuring the angle of recession for the pinion of the Williams system, it is first necessary to note the location of the center of the generating circle in reference to the center of the pinion and then to ascertain the inclination of the straight line connecting these two center points, with a plane normal to the common axes plane of the gear and pinion. With such relations established, the selection of the proper set of equations for the rectangular coordinates of the point of tooth contact termination is apparent.

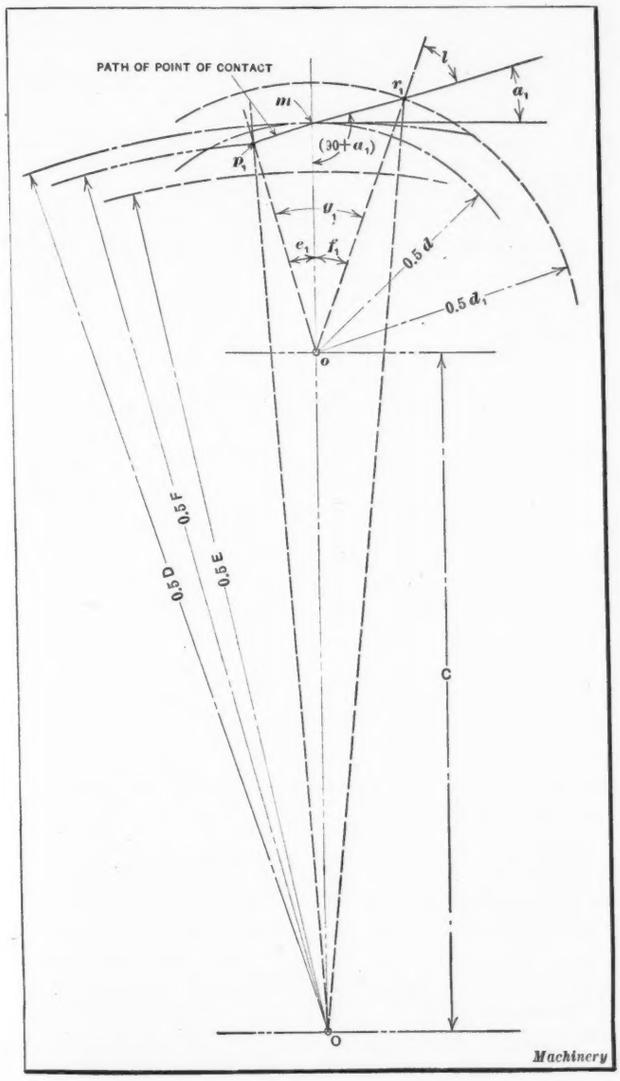

Fig. 3. Diagram used in Involute System of Internal Gearing Formulas

Case 1

When $C > B$ and $j + k < 90$ degrees.

$$N = A - R \cos (j + k) \quad (12)$$

$$N_1 = R \sin (j + k) \quad (13)$$

Case 2

When $C > B$ and $j + k > 90$ degrees but $<$ (90 degrees $+ h$).

$$N = A + R \cos (180 \text{ degrees} - j - k) \quad (12a)$$

$$N_1 = R \sin (180 \text{ degrees} - j - k) \quad (13a)$$

Case 3

When $B > C$ and $k - j < 90$ degrees.

$$N = A - R \cos (k - j) \quad (12b)$$

$$N_1 = R \sin (k - j) \quad (13b)$$

Case 4

When $B > C$ and $k - j > 90$ degrees but $<$ (90 degrees $+ h$).

$$N = A + R \cos (180 \text{ degrees} - k + j) \quad (12c)$$

$$N_1 = R \sin (180 \text{ degrees} - k + j) \quad (13c)$$

Case 5

When $C > B$ and $j + k = 90$ degrees $+ h$, or when $B > C$ and $k - j = 90$ degrees $+ h$

$$N = A + R \sin h \quad (12d)$$

$$N_1 = R \cos h \quad (13d)$$

Case 6

When $C > B$ and $j + k > 90$ degrees $+ h$, or when $B > C$ and $k - j > 90$ degrees $+ h$

$$x = (R + \sqrt{A^2 + B^2}) \sin h \quad (12e)$$

$$y = (R + \sqrt{A^2 + B^2}) \cos h \quad (13e)$$

$$\tan f = \frac{N}{K} \quad \text{(Cases 1 to 5 inclusive)} \quad (14)$$

$$\tan f = \frac{x}{y - C} \quad \text{(Case 6)} \quad (14a)$$

$$g = e + f \quad (15)$$

Equations and Formulas for Involute Gear System
(Reference Fig. 3)

$$a_1 = e_1$$

$$\sin l = \frac{0.5d \cos e_1}{0.5d_1} \quad (16)$$

$$f_1 = 90 \text{ degrees} - a_1 - l \quad (17)$$

$$g_1 = e_1 + f_1 \quad (18)$$

Examples Showing Graphic Comparison of Arc of Contact of Involute and Williams Internal Gear Systems

Williams System—In a 4-pitch internal gear combination, having a 20-tooth gear and a 12-tooth pinion, find the angle which measures the arc of contact of the pinion when the tooth space angle of the internal gear is 29 degrees, and when the center distance is 1 inch.

By the conditions of the problem $D = 5$ inches; $d = 3$ inches; $c = 14\frac{1}{2}$ degrees; $d_1 = 3.5$ inches; $E = 4.5$ inches.

$$a = 14.5 + \frac{90}{20} = 19 \text{ degrees}$$

$$R = 0.25 \times 5 \times 0.94552 = 1.182 \text{ inches} \quad (1)$$

$$A = 1.182 \times 0.32557 = 0.385 \text{ inch} \quad (2)$$

$$B = 0.5 \times 5 - (1.182 \times 0.94552) = 1.3824 \quad (3)$$

$$\tan h = \frac{0.385}{1.3824} = 0.2785 \quad (4)$$

whence

$$h = 15 \text{ degrees } 34 \text{ minutes}$$

$$\cos n = \frac{0.385^2 + 1.3824^2 + (0.25 \times 4.5^2) - 1.182^2}{4.5\sqrt{0.385^2 + 1.3824^2}} = 0.8865 \quad (5)$$

whence

$$n = 27 \text{ degrees } 34 \text{ minutes}$$

$$n - h = 12 \text{ degrees}$$

$$M = 0.5 \times 4.5 \times 0.20791 = 0.468 \text{ inch} \quad (6)$$

$$M_1 = 0.5 \times 4.5 \times 0.97815 = 2.201 \text{ inches} \quad (7)$$

$$J = 2.201 - 1 = 1.201 \text{ inches} \quad (8)$$

$$\tan e = \frac{0.468}{1.201} = 0.3897 \quad (9)$$

whence

$$e = 21 \text{ degrees } 18 \text{ minutes}$$

$$G = B - C = 1.3824 - 1.00 = 0.3824 \text{ inch}$$

$$g = 21 \text{ degrees } 18 \text{ minutes} + 24 \text{ degrees } 45 \text{ minutes} = 46 \text{ degrees } 3 \text{ minutes} \quad (15)$$

Involute System—In a 4/5-pitch internal gear combination having a 20-tooth gear and a 12-tooth pinion, find the angle which measures the arc of contact of the pinion when the pressure angle of the gear teeth is 20 degrees and the center distance 1 inch.

By the conditions of the problem $D = 5$ inches; $d = 3$ inches; $d_1 = 3.4$ inches; $E = 4.6$ inches.

$$e_1 = a_1 = 20 \text{ degrees}$$

$$\sin l = \frac{0.5 \times 3 \times 0.93969}{0.5 \times 3.4} = 0.8291 \quad (16)$$

whence

$$l = 56 \text{ degrees}$$

$$f_1 = 90 \text{ degrees} - 20 \text{ degrees} - 56 \text{ degrees} = 14 \text{ degrees} \quad (17)$$

and

$$g_1 = 20 \text{ degrees} + 14 \text{ degrees} = 34 \text{ degrees} \quad (18)$$

Reduction of Wear

The lengths of the arcs of contact for the respective systems also indicate the relative wearing qualities of the gears, though not exactly. In both systems, the wear is more pronounced on the pinion than on the internal gear, but in the case of the involute pinion the wear is considerably

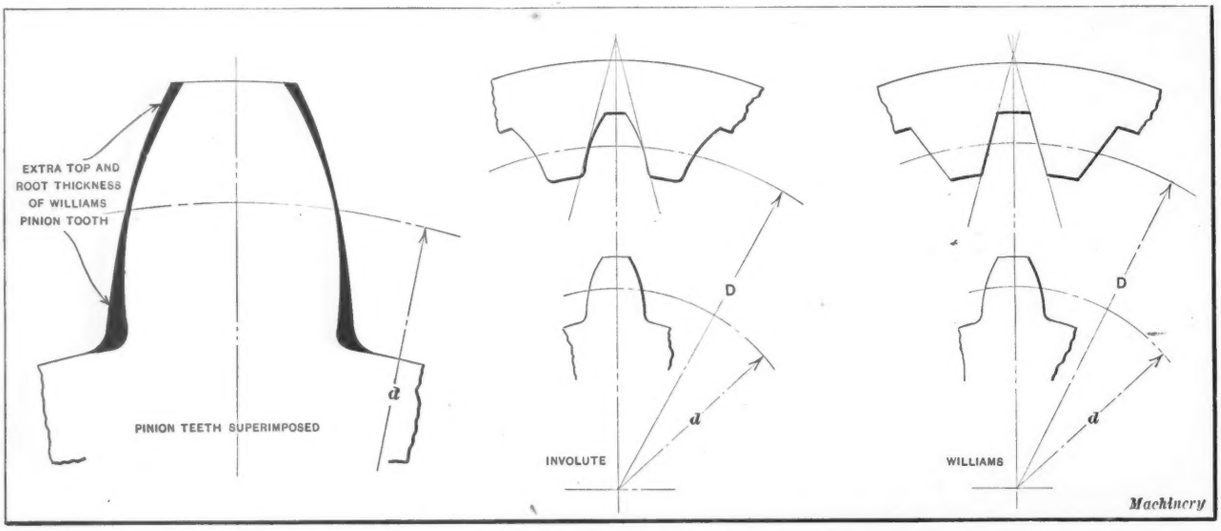

Fig. 4. Diagrammatic Comparison of Williams and Involute Internal Gear Teeth Forms

$$\tan j = \frac{0.3824}{0.385} = 0.99325 \quad (10)$$

whence

$$j = 44 \text{ degrees } 48 \text{ minutes}$$

$$\cos k = \frac{1.182^2 + 0.385^2 + 0.3824^2 - (0.25 \times 3.5^2)}{2 \times 1.182\sqrt{0.385^2 + 0.3824^2}} = -1.07 \quad (11)$$

The above value (—1.07) is an impossible cosine and indicates that the last point of tooth contact lies on the path of point of contact somewhere before the outer diameter of the pinion intersects this contact arc. This means that in this particular example, the conditions are such that the side *ro*, Fig. 1, which is opposite angle k, is less than the radius $0.5d_1$. It is evident then, that although B is greater than C, $j - k$ must be as great as, but cannot be greater than the angle 90 degrees + h. It also follows that the conditions of the problem are not satisfied by either Cases 3, 4, or 6 but by Case 5; therefore

$$N = 0.385 + (1.182 \times 0.26836) = 0.7022 \text{ inch} \quad (12d)$$

$$N_1 = 1.182 \times 0.96332 = 1.1386 \text{ inches} \quad (13d)$$

$$\tan f = \frac{0.7022}{1.1386 + 0.3824} = 0.46101 \quad (14)$$

whence

$$f = 24 \text{ degrees } 45 \text{ minutes}$$

greater. In the more familiar construction, there is a concentration of wear upon the shank of the pinion, with an easing off on the shank of the internal gear teeth.

The result of the concentration of wear in the involute system, even in a minor degree, is the objectionable backlash which tends to make the gears noisy in operation by increasing the shock of contact. In the Williams construction, however, the wear is more evenly and effectively distributed over the tooth profiles on account of the longer arc of contact; also the wear which is concentrated to some slight degree on the shanks of the pinion teeth, is similarly concentrated on the shanks of the internal gear teeth, so that a slight wear tends to relieve the shock of contact without developing backlash. In the involute system, the backlash accelerates the wear, while the "relief" in the Williams system tends to transfer the wear to mid-tooth sections without "knock" or tendency to cause abrasive action between engaging teeth.

Strength

In all tooth gearing the pinion, being invariably the weaker member, governs the strength of the combination. The Williams system is no exception to this rule, but the strength of the pinion teeth is considerably greater than in the involute system, in which the strength of the pinion teeth is reduced by under-cutting. This objectionable feature is much less marked in the Williams pinion than in an

involute pinion, for the reason that the tooth space across the tops of adjacent teeth is greater in the former type. For a similar reason, the top thickness of Williams pinion teeth is greater than that of teeth of corresponding involute pinions—the tooth space width at the roots of the gear teeth consequently being greater in the Williams system. This distinctive superiority of the Williams construction is brought out clearly in the comparison of pinion teeth shown in Fig. 4. The smaller diagrams in the illustration depict tooth spaces of the respective systems and demonstrate the cause of the difference in the form of the mating pinion teeth. The curved profiles of the involute gear teeth are concave and recede from the contact planes tangent on the pitch line,

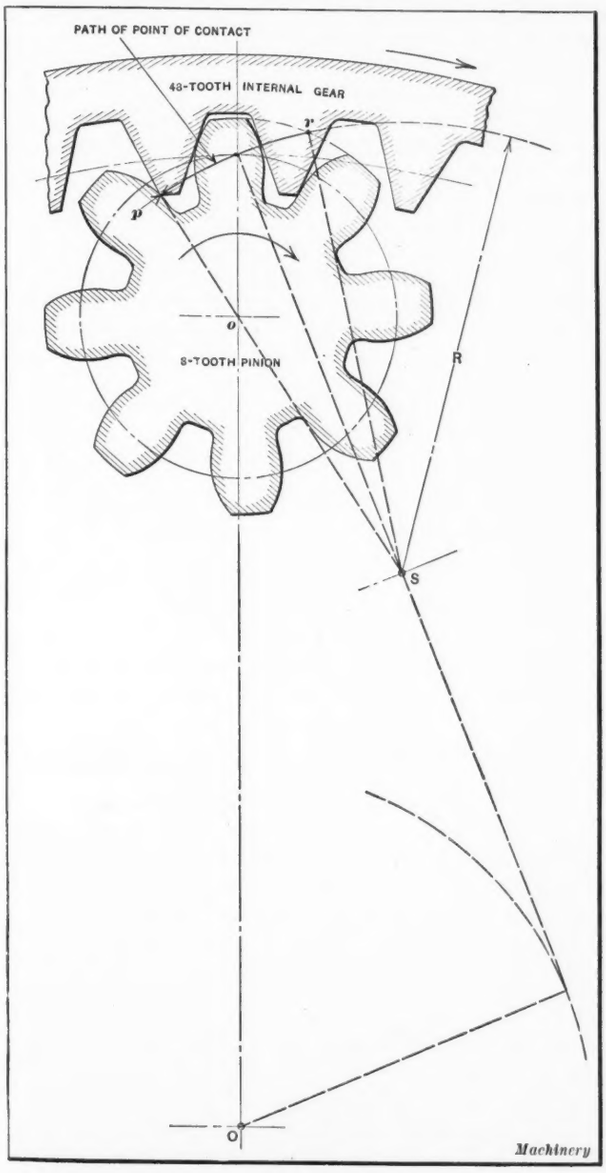

Fig. 5. Special Combination of Williams Internal Gearing, Ratio 6 to 1

while the profiles of the Williams internal gear teeth lie in the contact planes. As previously referred to, the larger diagram, showing the pinion teeth superimposed, illustrates the extra top and root thickness of the Williams pinion tooth.

The pinion tooth forms selected for comparison are chosen so as to favor the involute form, that is, the involute pinion tooth is one free from serious under-cutting. It is a 20-degree tooth of 80 per cent stub form—proportions which materially increase the strength of the involute tooth. Such a tooth is approximately 40 per cent stronger than a 14½-degree involute tooth of standard proportions and the same pitch. The Williams form of pinion compared with the 20-degree stub involute tooth illustrated is about 36 per cent stronger, the strength of the teeth varying with the square of their respective root thicknesses. Thus it is evident that, if the increased arc of contact for the Williams system is taken into account, a Williams "14½-degree combination" is actually stronger than a similar gear combination with 20-degree involute teeth of stub form.

An interesting combination of Williams gears is shown in Fig. 5, in which the strength of the gearing, measured by the strength of the 8-tooth pinion, is materially increased by making the pinion teeth as strong as the gear teeth. This is accomplished by increasing the thickness of the pinion teeth and correspondingly decreasing the thickness of the internal gear teeth, so that the root thicknesses of the respective teeth are the same. The circular pitch of the gears is not altered, the thickness of the pinion tooth simply being increased and the space between adjacent gear teeth widened by reducing the thickness of the gear teeth.

Reduction in Size of Pinion

This method of securing a high speed ratio with a pinion of few and unusually strong teeth cannot be resorted to as effectively with gears proportioned according to the involute system, as in such designs the under-cutting of a pinion having less than 10 or 12 teeth would be excessive. On the other hand, a Williams pinion with a considerably smaller number of teeth is a feasible and practical construction, for the pinion teeth are of generated conjugate form for operation with an internal gear of specific size. If the pinion tooth can be so generated, it can be produced with assurance that it will operate successfully with its "master" gear, without developing interference of teeth. An involute pinion with a small number of teeth can be generated, of course, provided the under-cutting is not too pronounced, but it will not operate in combination with an involute gear. Radical modifications of the involute profiles might enable a so-called involute combination to function, but the under-cutting of the pinion teeth would be so marked as to make them unduly weak.

The Demand for Internal Gearing

Any further enlargement upon the advantages of the Williams system of internal gearing, the more obvious of which have been pointed out, would seem unnecessary, but a word or two in respect to the importance of the development at this time will not be amiss. In other words, what is the present demand for internal gearing?

The advantages of the internal form of gearing are well known and generally conceded, but the demand for a system of efficient internal gears that can be produced at comparatively low cost may not be as well appreciated. However, there are one or two industries that even now realize the advantages of the construction. In the motor truck field, almost 25 per cent of all models of trucks are now being constructed with internal gears for the final drive reduction, and nearly 33 1/3 per cent of all farm tractors are propelled through some form of internal gear mechanism. One manufacturer of rear axle drives for motor trucks has alone placed in service nearly 100,000 internal gear combinations.

* * *

A brief account of the history, organization, and procedure of the United States Patent Office has been prepared by William I. Wyman, member of the Examining Corps, U. S. Patent Office, and has been published by the Patent Office Society, Washington, D. C. This historical review points out that the first patent granted on this continent was to Samuel Winslow by the General Court of Massachusetts in 1641. This patent was for a novel method of making salt. Connecticut also was active early in encouraging inventions, and required, as the basis of a patent grant, that the invention "shall be judged profitable to the country." The first legislative enactment of the Government of the United States establishing a protection for inventors was the law of 1790. The present system of patents was established in 1836.

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THE ECONOMIC PRINCIPLE OF WAGES

Employers everywhere are beginning to realize that they must do some educational work among their employes in order to give them a correct understanding of the true relation between production and wages. The war furnished an object lesson that may be used in this connection. While wages rose, the cost of living rose, in some instances, in even greater proportion; so it is quite evident that an increase of wages alone is of no benefit unless production keeps pace with the increase in wages, or so exceeds it that the cost of commodities, which means the cost of living, is not also raised quite as much as the wage rate.

In some of the neutral European countries, this object lesson was so clearly and so forcibly impressed that the workers began to understand the relation between wages and production. It became evident to them that no matter how high their wages were—and in some instances there was an increase of several hundred per cent—they were not benefited thereby when goods were so scarce that they were either not obtainable at all, or so expensive that even the increased wage was not sufficient to buy a reasonable amount of the necessities of life. This condition is not altogether a war condition; the same economic law is at work in peace times as well. There is but one way in which prices can be brought down, and that is by the production of *more* commodities at the *same* expenditure of time and money, so that the first cost may thereby be reduced.

Any effort, therefore, to prevent the application of efficient methods in factories, or to reduce production by other means, is a direct effort to increase the cost of the product and thus increase the cost of living; and the wage earner will suffer directly from any curtailment in production, no matter what his wages may be in dollars and cents. It is not a question of whether a man earns $3 or $6 a day, but how much will the money he earns buy in actual products; it is the exchange value of wages that counts. Therefore, to decrease the cost of living is equally as important to the wage earner as to increase his wages, and the only way in which the cost of living can be decreased is by increased efficiency and increased production, so that more commodities, more cheaply produced, will be offered for sale.

* * *

SKETCHING IN TOOL AND JIG DESIGN

The value of accurately made free-hand sketches is not as well understood as it should be. Both machine and tool designers will, therefore, find the article "Mechanical Sketching" in this number of MACHINERY, of considerable interest and value. Tool designers may use carefully made sketches to advantage for the preliminary lay-out of tools, jigs, and fixtures; for example, in connection with turret lathe practice, rough sketches may be made to show the possible arrangements of the tools, so as to determine as quickly as possible the most efficient method of machining. Special chucks and work-holding fixtures may also be shown in these sketches. In many cases, these rapidly drawn lay-outs, especially if fairly accurate, will serve the same purpose as drawings made to scale.

When developing the design of a jig or fixture, sketches are particularly valuable. Often a sketch which is made in a few minutes shows that an idea which seemed at first thought to be good, is entirely impracticable. On the contrary, if the design appears to be satisfactory, a scale drawing showing the exact arrangement of the different parts can be made from the sketch by a draftsman who has not had the experience or training to develop original designs. As the design of many special tools and of jigs and fixtures depends upon the shape of the work, the preliminary sketches should be made around a drawing of whatever part the tool or jig is intended for. Ink or a colored pencil may be used for this outline drawing of the work to secure greater contrast with the sketch of the tool or jig itself. It may be advisable to make a fairly accurate drawing of the work. Sometimes cross-sectioned paper is especially useful when developing the designs of new tool equipment, in order to insure greater accuracy in sketching. The squares on the paper serve as units of measurement, and the sketch may be drawn almost as accurately as when instruments are used.

* * *

WHAT THE "SAFETY FIRST" CAMPAIGN HAS ACCOMPLISHED

It is less than fifteen years ago since the effort to reduce accidents in the industries took definite form. As MACHINERY was one of the first journals to actively enlist in the campaign then started, it is all the more gratifying to record here the official figures recently published by the Bureau of Labor Statistics.* These show to what an extent industrial accidents have been reduced through the methods developed and the safeguards provided as a result of the Safety First Campaign. The reports show that accidents in the iron and steel industries were decreased more than two-thirds from 1907 to 1917. While in 1907, 245 men were either killed or injured for a certain number of men employed, this rate was reduced to 81 for the same number of men in 1917.

It is stated that a further reduction would have been recorded in 1917 but for the changes in industrial processes made necessary in order to meet the war demands. Machinery and apparatus could not be kept up in good condition and a great many unskilled and inexperienced men were employed during the war. A great many of the accidents must be charged to these conditions, because it is stated that among the most prominent causes of accidents during 1917 were defective machinery and the employment of inexperienced men. The present tendency toward more thorough training of men in the mechanical industries will aid in still further decreasing the number of accidents caused by inexperience; and the number caused by defective machinery will be materially reduced in peace time because of the less strenuous service to which machines and shop equipment will be put.

Can Germany Regain Her Russian Trade?

Cecil B. Harmsworth, Under Secretary of State for Foreign Affairs of Great Britain, recently stated in the House of Commons that the German Government is believed to be trying to establish trade relations with Soviet Russia and that a German Industrial and Commercial Mission has visited or is about to visit Russia with this purpose in view. This statement gives added interest to the present article, giving information concerning the volume of trade of Russia previous to the war and the trade centers that —when normal conditions once more return—are likely to regain their former importance. Manufacturers in the United States who make their foreign trade plans far in advance have expressed interest in Russian conditions because they believe that, after all, the trade with Russia will be one of the most important outlets for American machinery and metal products, even though it may be some time before the Russian trade channels will be reopened. Acknowledgment is made to R. Martens & Co., 6 Hanover St., New York City, for the specific data presented both in the tables and in the text of this article.

FOR over half a century before the war stopped commercial intercourse between the two countries, manufacturers in Germany were systematically establishing trade connections in Russia. This work was conducted with all of the well-known Teutonic efficiency, and immediately before the outbreak of war in 1914, German business men had a virtual monopoly upon many classes of Russian trade. Both European Russia and Siberia are included among the territories of the world still possessing vast natural wealth which has not been exploited; and for several reasons it is to be expected that these great undeveloped resources will lead to a rapid industrial development of the country. Important among these reasons is the fact that both the war and the subsequent revolutions have created what amounts to an intellectual awakening among the Russian people. Many of the old bureaucratic institutions have been abolished, and when a stable form of government is once more set up, there is every reason to feel confidence in the future of the country. Many men of sound judgment believe that wartime conditions have paved the way for a period of rapid industrial expansion, which will create excellent opportunities for the importation of machinery and other factory equipment made in America. But the question is asked by those who are investigating the merits of this potential market, "Can Germany regain her Russian trade?"

Changed Viewpoint of American Business Men

Before the war, there were a large number of manufacturers engaged in making products that could have been profitably sold abroad, who never made any systematic effort to enter foreign markets. This situation has been greatly changed during the last four years. The large volume of profitable European trade which came to our country during the war has shown conclusively the possibilities of foreign markets if they are properly cultivated; and the desire for export business has been further stimulated by the necessity of finding an outlet for the product of manufacturing plants which have, in many cases, been largely increased in order to provide facilities for the execution of government orders.

Those who are now making a study of future Russian trade possibilities recognize the fact that the answer to whether the business men of this country can obtain a share of the future trade with Russia will depend largely upon the question of how successful German manufacturers find themselves in reestablishing their Russian connections. American firms that are planning a sales campaign in Russia are especially cautioned against assuming that the war will have created an insurmountable prejudice against German goods which will make it easy for the American salesman to fill his order books with business that formerly went to Germany. One obstacle to overcome is the fact that most Russian merchants have grown familiar with German business methods, and know the German language. Just as French is recognized as the diplomatic language of Europe, so German is the commercial language of Russia.

Importance of Studying the Customers' Requirements

German business men have not only established offices and made friends in the commercial centers of Russia, but what is more important, they have carefully studied the requirements of their customers and have, in many cases, changed the design of their products in order to make them especially adapted to local conditions. By citing a simple example, this point will be made clear. Some years ago, the files made in Sheffield, England, were used almost exclusively in Russia, but gradually this trade was taken over by the Germans. What was the reason? Sheffield manufacturers were in the habit of delivering files of sufficient thickness so that when the teeth were worn out they could be recut several times before the file was discarded. In Great Britain and other manufacturing countries, where there are shops prepared to recut files at a nominal cost, this form of tool allows a customer to obtain additional service at a relatively low cost. But in most parts of Russia, there is practically no chance of having a file recut, and so the British file with its thick blade represented an additional first cost for steel without any additional service obtained through recutting the teeth.

German file manufacturers were quick to recognize this point, and entered the Russian market with files having very thin blades. These were equally efficient so long as the original teeth lasted, and when the teeth became dull the file was simply discarded. As less steel was required to make such files, they could be sold at a lower first cost, and so they were able to compete on such successful terms that the German file makers soon acquired a virtual monopoly in this line.

The example which has just been cited is a simple one, but there is a big fundamental principle involved, and the manufacturer who hopes to get and to hold business in Russia must be prepared to either send capable men into the field to study local conditions and make trustworthy reports as to the requirements of the trade, or else he must place his product in the hands of an experienced and reliable dealer.

Can the Germans Regain their Trade in Russia?

When the old trade routes are once more open to the commerce of the world, Germany will make a tremendous drive to regain her foreign trade. A special incentive in this direction will be created by the financial burden which has been placed on German business houses through over five years of greatly restricted activity. From the preceding discussion it will be apparent that unless the Russians are prejudiced against German goods as a result of the war, German manufacturers have a considerable advantage in the competition which will arise for Russian trade. Also, there are other special reasons why the Germans will make a most strenuous effort to reestablish themselves in this field. Important among these is the mineral wealth of the country and the losses of territory which the Germans have suffered as a result of their military defeat.

All readers of the daily papers followed the reports of the discussion which occurred in Paris over giving to France

the mineral rights of the Saar Valley to compensate her for the damage which the Germans did to the coal mines in France. Added to this, the loss of Alsace-Lorraine deprives the Germans of practically all of the rich iron ore which supplied the needs of their industry, and leaves them with nothing but relatively poor grades of ore at their disposal. Quite obviously, the electrical, mechanical, and allied industries of the Germans cannot prosper without a supply of ore of a grade which will make good iron and steel, and with their late source of supply cut off, attention of the Germans will naturally be turned to the extremely high grades of ore which are found in large quantities in the Caucasus district of Russia.

A similar situation exists in regard to copper, which is an essential of the electrical industry. Prior to the outbreak of war in 1914, German firms had a virtual monopoly on electrical apparatus sold in Russia, but before they can start upon a campaign to regain any of this trade, it will be necessary to acquire a supply of copper. The best information seems to indicate that Germany has been almost entirely stripped of copper for manufacturing munitions, and it will probably be some time before this supply can be replaced. In the meantime, American manufacturers of electrical equipment and supplies will have an excellent opportunity of entering the Russian field and forming connections which, with proper care, it should be difficult for a competitor to supplant later on. The copper situation and its relation to the electrical trade will, however, offer still another incentive for Germany to regain her hold in Russia, because there are valuable deposits of copper in the Caucasus, the Ural Mountains, and Siberia. Also, virtually all of the world's supply of platinum comes from mines in the Urals.

Map of Russia showing Important Trade Centers

Condition of Russian Industry before the War

In order to form a reliable idea of the probable volume of business that is to be obtained in Russia today, it will be of interest to briefly review industrial conditions of that country pior to the outbreak of war. Agriculture is one of the leading Russian industries, and for that reason there is a large demand for various types of agricultural machinery. Prior to 1914, it was estimated that more than half of the equipment used on farms was of the very crude types which the peasants made for their own use; and that a large part of the remainder was imported from the United States. This fact is of interest because of its probable relation to the changed viewpoint in Russia which has been created by the war. Over 15,000,000 men were enlisted in the army, and a large percentage of this number came from rural communities in which agriculture affords practically the only means of livelihood. Hundreds of thousands of these uneducated peasants were brought into contact with ways of life with which they were formerly unacquainted, and they were taught the use of automobiles, tractors, trench diggers and numerous other mechanical appliances, which has doubtless gone a long way toward giving them an entirely new point of view. Also, there were great numbers of Russian prisoners of war in Germany, who were employed in factories, mines, or on the land, and were taught the use of up-to-date machinery. For these reasons, it is felt that in the future there will be a far better opportunity to sell the Russians improved types of machinery which will enable them to perform their daily tasks with far greater rapidity and with a reduced amount of manual labor.

Management of the Steel Industry—Selling Machinery through Dealers

Continuing with the statement of industrial conditions in Russia it may be mentioned that the steel industry of that country was largely developed by the Belgians, and that an excellent grade of rails and structural shapes were made in sufficient volume so that there was a surplus for export after the domestic requirements had been supplied. The same was not true of plates, however, as these were of poor quality. As regards machine tools, very few were built in Russia and it is estimated that over 75 per cent of those used in the whole country were imported—many from America. The selling of American tools was not done direct, however, as most of the orders passed through German dealers.

It is interesting to note in this connection that just prior to the outbreak of war in 1914, many of these German firms were losing friends in Russia owing to their somewhat arbitrary methods of doing business. The established policy of these firms was to try to obtain nothing but large orders, and where manufacturing plants were in a position to place orders for a large volume of machine tools, but would not give the entire order to one dealer, it was not unusual for him to show very little interest in selling the few machines that were required. Probably some of these little weaknesses of the German dealers will be remembered in years to come, and as a result, American firms who formerly employed these agents to represent them in Russia, should be able to arrange for the direct sale of their machines to the Russian trade.

Made "Out" of Germany

"Made in Germany" is no longer the slogan proudly imprinted upon the manufactured products of that country.

TABLE 1. GENERAL EXPORTS FROM RUSSIA IN 1913

Values given in table are in millions of dollars, based on normal rates of exchange

Country	Millions of Dollars	Country	Millions of Dollars
Germany	226.80	Roumania	10.85
England	133.90	United States	7.10
Holland	88.70	Sweden	5.70
France	50.45	Spain	4.45
Italy	36.90	Egypt	4.35
Austria-Hungary	32.65	Greece	3.45
Belgium	32.35	Norway	3.35
Persia	28.85	Afghanistan	2.95
Finland	27.65	Bulgaria	1.15
Denmark	18.20	Japan	0.70
Turkey	17.90	Other countries	5.90
China	15.75		

Machinery

TABLE 2. GENERAL IMPORTS INTO RUSSIA IN 1913

Values given in table are in millions of dollars, based on normal rates of exchange

Country	Millions of Dollars	Country	Millions of Dollars
Germany	326.10	Denmark	6.45
England	86.50	Norway	4.90
China	42.05	Belgium	4.45
United States	39.55	Afghanistan	3.15
France	28.50	Spain	2.85
Finland	25.50	Egypt	2.95
Persia	21.80	Switzerland	2.60
Austria-Hungary	17.85	Japan	2.40
East Indies	17.25	Greece	0.95
Holland	10.70	Serbia	0.90
Turkey	9.20	Portugal	0.75
Sweden	8.45	Roumania	0.70
Italy	8.40	Other countries	5.00
Ceylon	7.10		

Machinery

It is realized that a wiser course will be to disguise the fact that exports are of German origin, wherever such a course is possible. Among builders of machinery and manufacturers of small tools it is probably a matter of fairly general knowledge that German machinery dealers and manufacturers have established offices and assembling plants in Sweden and Denmark, through which it is proposed to do business in Europe. The idea is, of course, to so camouflage this trade that it has the appearance of emanating from the Scandinavian countries while, as a matter of fact, it is strictly German. Propaganda to expose this system might be employed advantageously in certain cases, where American houses are operating direct in Russia. Men who are most familiar with conditions state that it would be well worth while for large builders of machine tools and manufacturers of machinists' small tools to establish sales offices in Russia. The large manufacturing corporations have grown familiar with the products of the better known American builders of machine tools, and there would be no insurmountable difficulty in arranging for their direct sale from the United States.

Trade Centers of Russia

Manufacturers who consider the establishment of such sales offices would be wise to give careful consideration to the relative merits of the following cities as a location: Petrograd, Moscow, Warsaw, Riga, Baku, Kiev, Kharkoff, Ekaterinburg in the Ural Mountains, and Barnaoul in Siberia. Petrograd is placed at the head of this list because it was the national capital of Russia, but business men who know the affairs of that country express doubt concerning the wisdom of Peter the Great in transferring the capital from Moscow. The latter city is the geographical center of the country, and in many ways it is far better adapted for the national capital than is Petrograd, where it has been found impossible to improve the very poor sanitary conditions of the city caused by the low level of the land. For this and various other reasons it is predicted that the more important business of the country is likely to be done in Moscow in the future.

Machine tool builders and other manufacturers who are considering the institution of direct sales campaigns will naturally be interested in learning of the best way in which to route shipments of goods. These should be sent either via Odessa or one of the Baltic ports, even in cases where the destination is as far east as the western part of Siberia. For shipments to eastern Siberia, it would naturally be more desirable to send goods to San Francisco or one of our Pacific ports for shipment via Vladivostok; but this is unimportant, because for many years to come there is not likely to be much of a demand for machinery or tools in eastern Siberia.

Value of Russian Imports and Exports

Manufacturers who are at present planning to develop their export trade, will naturally wish to give very careful consideration to the probable volume of business that could be done with those countries in which they propose operating. Bearing this fact in mind, tables have been compiled for publication in connection with this article, showing the values of Russian imports and exports. These data are for the year 1913, the latest period for which information is available based upon normal trade conditions. A third table has also been compiled, which presents a partial analysis of the different manufactures and commodities that come under the Russian customs return for the heading of "Ores, Metals, and Metal Manufactures," which includes all classes of machinery and metal goods. There is an interesting point in connection with the items included under this heading; namely, that of a total value of 1,374,000,000 rubles ($687,000,000) for Russian imports, the values of items coming under this group is 353,400,000 rubles ($176,700,000), that is to say, 25.7 per cent of the total. In connection with Tables 1 and 2, which give the values of Russian imports from and exports to various countries, particular attention is called to the great preponderance of this trade which was in the hands of the Germans prior to the war. This naturally suggests the possibility of diverting much of this trade to American firms, if a careful sales campaign is initiated before the Germans are able to reestablish themselves in Russia.

TABLE 3. ANALYSIS OF MACHINERY AND METAL IMPORTS INTO RUSSIA IN 1913

Values given in table are in millions of dollars, based on normal rates of exchange

Classes of Machinery	Germany	England	United States	Sweden	Austria	Denmark	France	Holland	Belgium
Various machinery	33.85	6.85	2.70	0.80	0.80	....	....	....	....
Agricultural machinery	4.95	1.15	2.65	1.10	1.55	0.80	....	....	....
Vehicles	9.00	1.05	....	....	....	....	0.55	....	....
Parts of machinery	6.75	1.15	0.60	....	....	....	....	....	....
Complex agricultural machinery	1.50	1.85	1.75	1.00	....	0.65	....	....	....
Electrical machinery	4.65	0.25	....	....	0.15	....	....	....	....
Cast iron, iron, and steel	3.25	0.80	....	0.35	0.25	0.15	0.10	0.15	0.1
Portable machines	1.25	2.15	....	0.10	0.10	....	....	....	....

Machinery

New National Acme Screw Products Plant

THE National Acme Co., Cleveland, Ohio, has recently completed what is believed to be the largest screw products plant under one roof in the world. This plant is known as the Coit plant, and is located at the junction of E. 131st St., Coit Road, Kirby Ave., and New York Central Railroad, Cleveland, Ohio. Through the completion of this plant, to which the company has moved its entire screw products department, the old plant of the National Acme Co. at Cleveland, Ohio, is released entirely for the manufacture of the company's line of Acme multiple-spindle automatic screw machines and secondary operation equipment, including self-opening dies and taps.

Statistics are dry, but the only adequate way in which to give an idea of the size of this plant is by means of figures. The plant consists of a stock-room and tool-room building of two stories, and a one-story sawtooth main manufacturing building, the total floor space of the whole plant being 8½ acres, of which 335,000 square feet of floor space (about 7½ acres) are covered by the one roof of the sawtooth building. The two-story building is 600 by 52 feet, while the main sawtooth building is 600 by 480 feet. The two-story building is of concrete construction, while the sawtooth building is of brick and steel construction with steel sash. In addition to the shop building, there is an executive office building, 112 by 50 feet, two stories and basement, built from reinforced concrete construction. This building is located in front of the shop building and is connected to it by a covered passageway. The plant employs a total of 1500 people, of which about 350 are women.

Some idea of the size of the building may be obtained from a few figures relating to the amount of material used in building the plant. The amount of structural steel is 2000 tons, and the wood-block flooring required 38,000 square yards of wooden blocks, equivalent to 94 carloads. There are 140,000 square feet of side-wall sash and 105,000 square feet of ventilating sash in the sawtooth roof. Measuring the glass in a 1-foot wide strip, there are 26½ miles of glass in the building, and 70,000 pounds of putty were used in connection with the glazing. In addition, 31 tons of paint were used in the painting of the main building.

Wide aisles, good and evenly distributed light, and provisions for fresh air of the right temperature characterize the plant. An unusually efficient heating and ventilating equipment has been installed. There are four heating and ventilating units, each unit consisting of a supply fan, vento-heaters, air washers, and return fans, vacuum pumps, circulating pumps, etc. The two larger units have a capacity of 90,000 cubic feet of air per minute, at a velocity through the washer of 450 feet per minute. The two smaller units have a capacity of 76,000 cubic feet of air per minute.

General Arrangement of the Plant

The plant is arranged with a view to having the material pass, as far as possible, in one continuous stream through the shop. The stock-rooms for raw materials are at one end of the plant, and from there the material passes to the various machines and departments by a direct route, after which the passage through the hardening and heat-treating

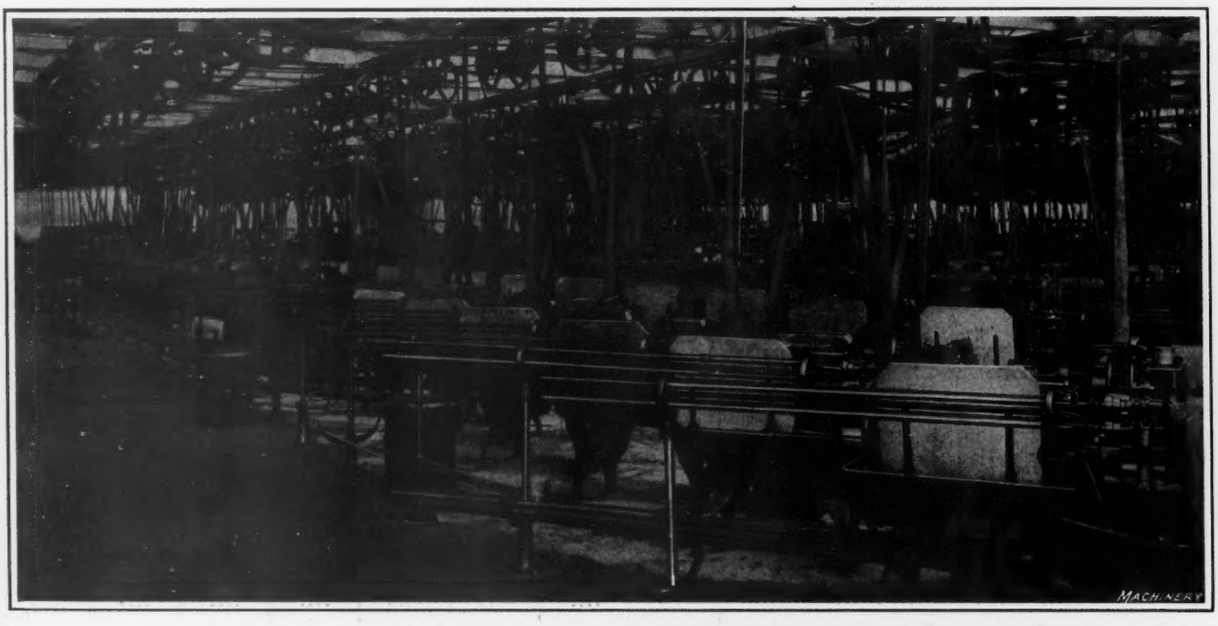


Fig. 1. General View in the Plant, indicating Arrangement of Machines and Broad Aisles provided

Fig. 2. View in the Cleaning Department, showing Pails of Parts and Scrap piled up, Ready for the Oil Extractors

rooms to the shipping room is made to cover a direct line as nearly as possible. In order to eliminate the hauling of finished material an unnecessarily long distance, the rather unusual arrangement of placing the cleaning department almost in the middle of the plant has been adopted. In most plants this department would be located at either end of the plant, requiring a long haul to and from this department. From the cleaning department, the parts pass either to the heat-treating department, to the shipping department—in case they are to go out immediately—or to the finished stock storage room, which is also quite centrally located, although toward one side of the plant.

Along that side of the plant where the raw stock room is located, a railway siding extends for the full length of the plant and an unloading platform is built at this side of a length sufficient for unloading twelve cars at once. As a rule, the outgoing product, except for shipment to branch warehouses, is not sent in carload lots, and hence is hauled by motor trucks to the respective freight stations, a special shipping platform being provided for the accommodation of the motor trucks. In cases where whole carload shipments are made, these are loaded at the unloading platform for raw material just mentioned.

An interesting feature in the management of the plant is that the gross screw machine product is not trucked through the plant during the day, but left until night, when it is brought from the automatic machines to the cleaning department by a night gang ready for the next morning when the material is passed through the oil extractors, where the oil adhering to the work and chips is first recovered. From the oil extractors, the finished material passes into chip removers or separators of special design having perforated sheet-metal screens. These screens permit the chips to pass through, while the screw products pass over the screen, which is oscillated in order to separate the chips from the work. After having passed through the separators, the screw product parts pass to steam washers, where the remaining oil is cleaned from the work as it passes through the cleaning machine in perforated-bottom metal boxes by means of a conveyor. After having passed through these washers, a light oil is poured over the parts to keep them from rusting. Afterward, the parts are sorted, weighed, inspected, and then sent either to the clearing house or to the stock-room. Heat-treated parts are sent to the heat-treatment department, and then returned for sorting and inspection.

The Equipment of the Plant

In order to gain an adequate idea of the size of the plant, a review of the equipment installed is necessary. In all, there are 600 Acme automatics, in addition to 60 milling machines, 46 bolt-threaders, 30 drilling machines, 16 screw-slotters, 29 stud-threaders, 155 nut machines, 65 nut tappers,

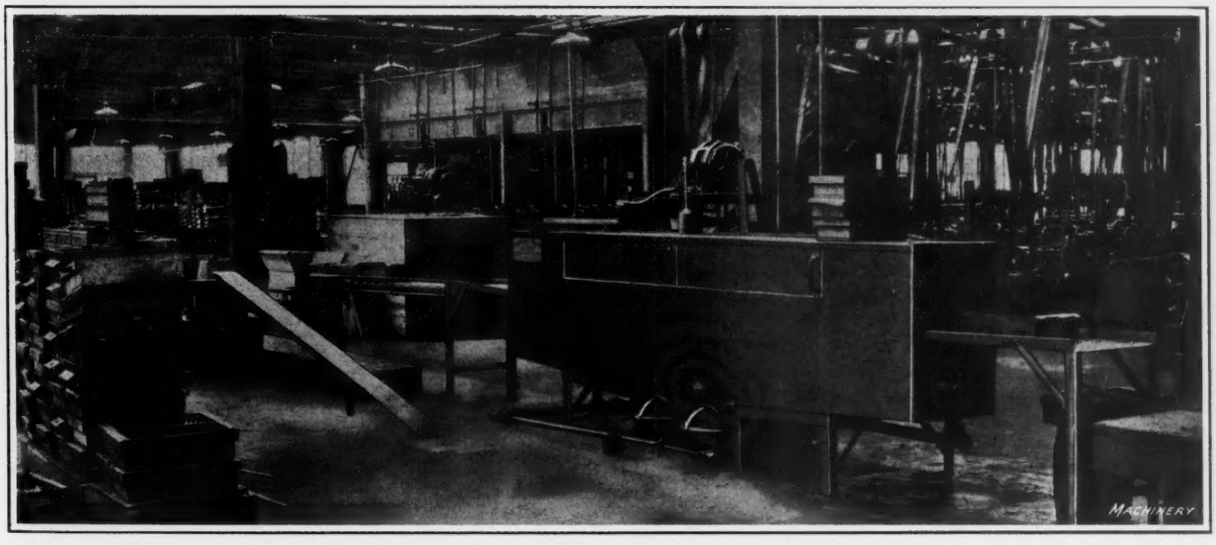


Fig. 3. Another View in the Cleaning Department, showing the Steam Washers

Fig. 4. A View in the Inspection Department, showing Individual Inspection Tables

119 castellating machines, in addition to a great number of other machines employed on secondary operations, the total number of machines in the plant being about 1800. The average production of the plant per month is 50,000,000 pieces. Specifying in detail the capacity of the different machines, it may be of interest to note that the bolt-threaders have a capacity of 500,000 pieces per day, the stud-threaders 100,000 pieces per day, threading both ends; the nut machines 600,000 nuts per day; and the nut tappers, 1,000,000 nuts per day. In addition, the hardening department has a capacity for handling 20,000 pounds of product in twenty-four hours.

In order to maintain this production 17,000,000 pounds of brass, steel, and iron are constantly kept in stock, and 200,000 pounds of stock are daily delivered to the automatic machines. The number of sheet-metal boxes necessary throughout the plant for holding the product while in process of manufacture is about 25,000, an average of 15,000 of which pass through the clearing house at the washing machines daily. About 50 tons of scrap are daily collected from the machines and put into the scrap pit. There are 20,000 gallons of cutting oil used per week, but 90 per cent of this amount is reclaimed.

Provisions Made for the Welfare of Employes

In building this plant, as well as in its management, considerable attention has been given to the comfort, convenience, and welfare of the employes. A hospital is provided where accidents can be quickly and efficiently taken care of, and where a great number of minor injuries are daily taken care of. A nurse is constantly on duty in the hospital and a physician is also there at certain hours every day.

A school has been provided for the women employes, giving them instruction in the English language and hygiene, classes being conducted daily. The course in English has proved to be an important feature, because as many as twenty-nine nationalities are represented among the employes.

Considerable attention has been given to provide a good lunch service for the employes. Space has been provided for a cafeteria seating 350 people. This cafeteria is intended for the office force and the women employes. There are also five additional serving stations provided throughout the plant for the shop men, these serving stations being capable of providing lunches for 850 men. Every feature has been studied with a view to providing maximum service at a minimum cost, so that good meals may be served at a low price, representing only the actual cost to the company.

Fig. 5. One of the Five Serving Stations provided throughout the Plant where the Men obtain their Lunches

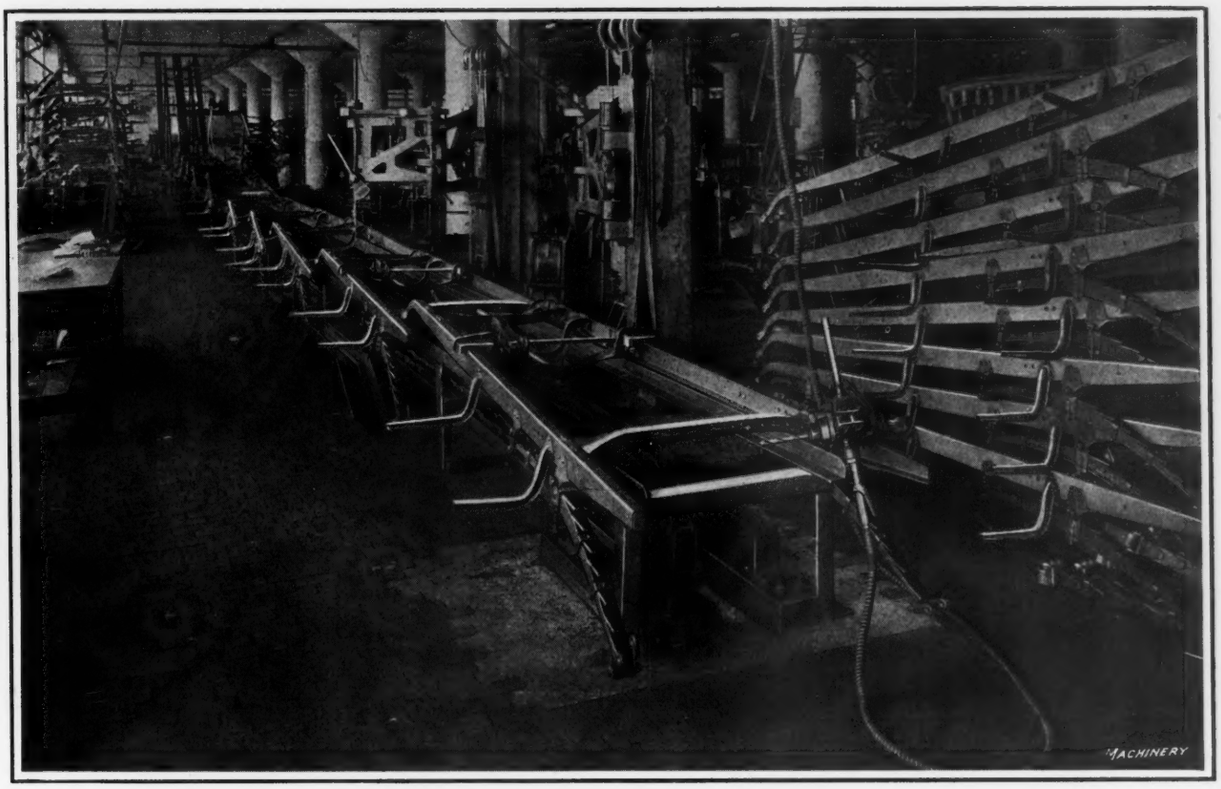


Fig. 12. Conveyor System used for carrying the Chassis from a Storage Space in the Basement to the Main Assembling Department on the First Floor of the Plant. This Conveyor carries the Chassis to the Starting Point of the Main Assembling Line

Automobile Factory Transportation Systems

Types of Equipment Used for Transporting Raw Materials and Parts of the Product through the Plant of the Willys-Overland Company in Toledo, Ohio—Second of Two Articles

By EDWARD K. HAMMOND

THE first article on this subject, published in the September number, described the methods and equipment employed by the Willys-Overland Co. in transporting the engine parts and finished engines through the plant, in assembling and upholstering the car bodies, and in handling the wheels, rims, and tires. The present article describes the progressive assembly of the complete cars and the conveyor systems for carrying the chassis, fenders, lamps, etc.

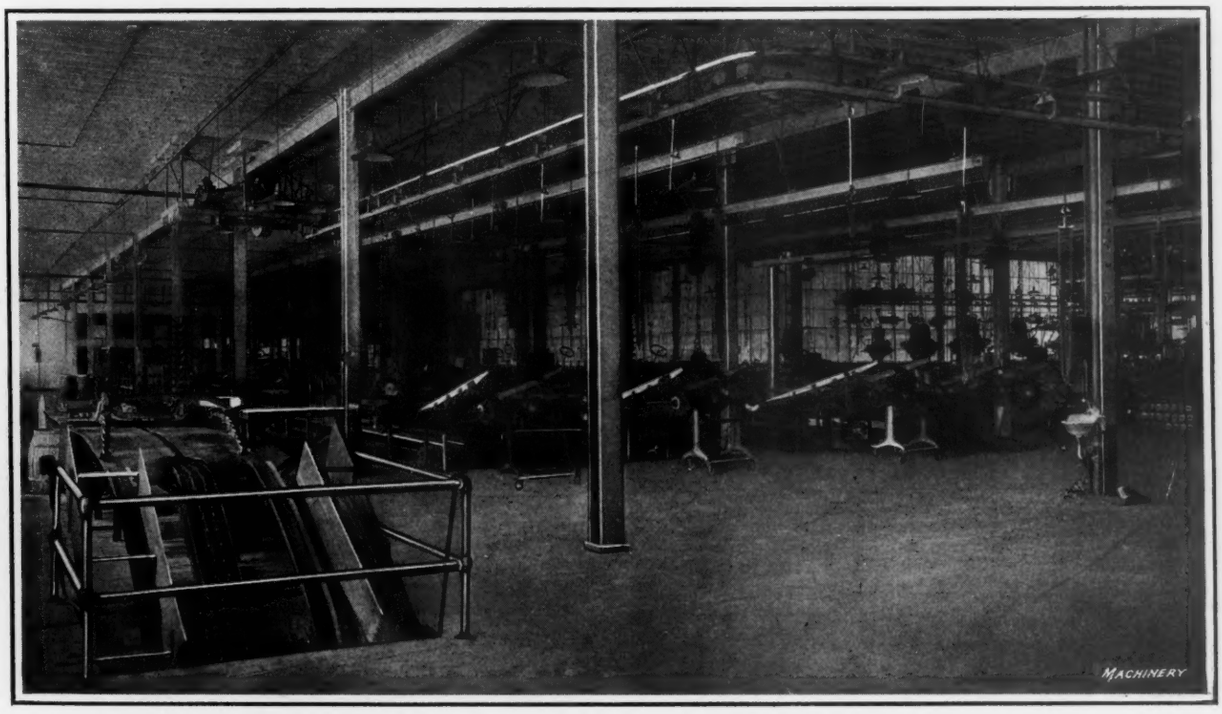


Fig. 13. Opposite End of Conveyor System shown in Fig. 12. The Four Main Assembling Lines will be seen at the Right

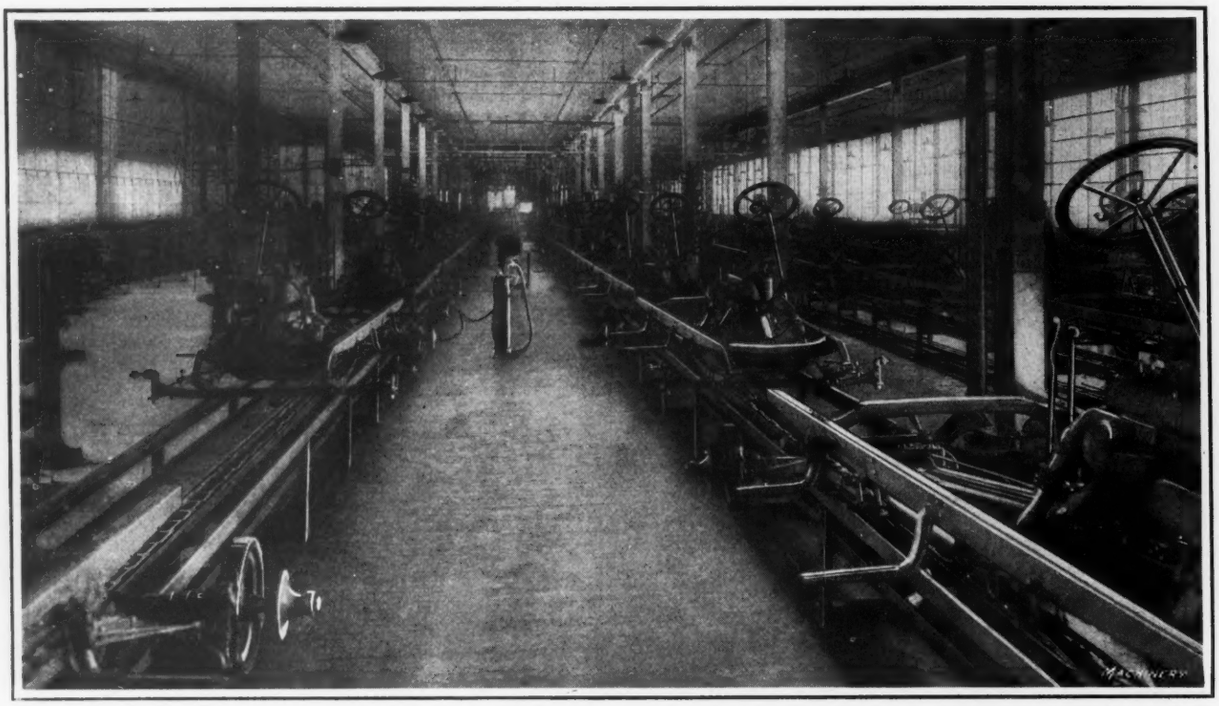


Fig. 14. View of Main Assembling Lines at a Point where the Engine and Steering Posts have been mounted on the Chassis

Progressive Assembly of the Complete Cars

The same general method of assembling is applied in the majority of plants engaged in automobile manufacture, although details naturally differ in each plant. In general, the method consists of starting the chassis at one end of a track, down which it is carried between two lines of men, each of whose duty it is to put a specified part on the partially finished car as it passes by the point where he is employed. In the Willys-Overland plant, and in other factories where the assembling department has been carefully organized, it is a practice to have a power-driven conveyor to carry the cars along this assembling track, so that a pace is set at which the men are compelled to work. This pace has been carefully determined, so that by a proper adjustment of the number of men employed at each station, none of those working in the assembling department are required to exert themselves to an extent which would be detrimental to their health. At the same time, the establishment of a uniform rate of working by all of the men protects the employer against the dishonesty of those who might otherwise be inclined to shirk their work. In most places where a power-driven progressive assembling equipment is used, the balance between the speed of the conveyor and the number of men employed has been worked out with such a degree of nicety that it is necessary to have substitutes stationed at intervals along the line for the purpose of taking the place of any man who has to temporarily leave his work. These substitutes have been trained in the performance of

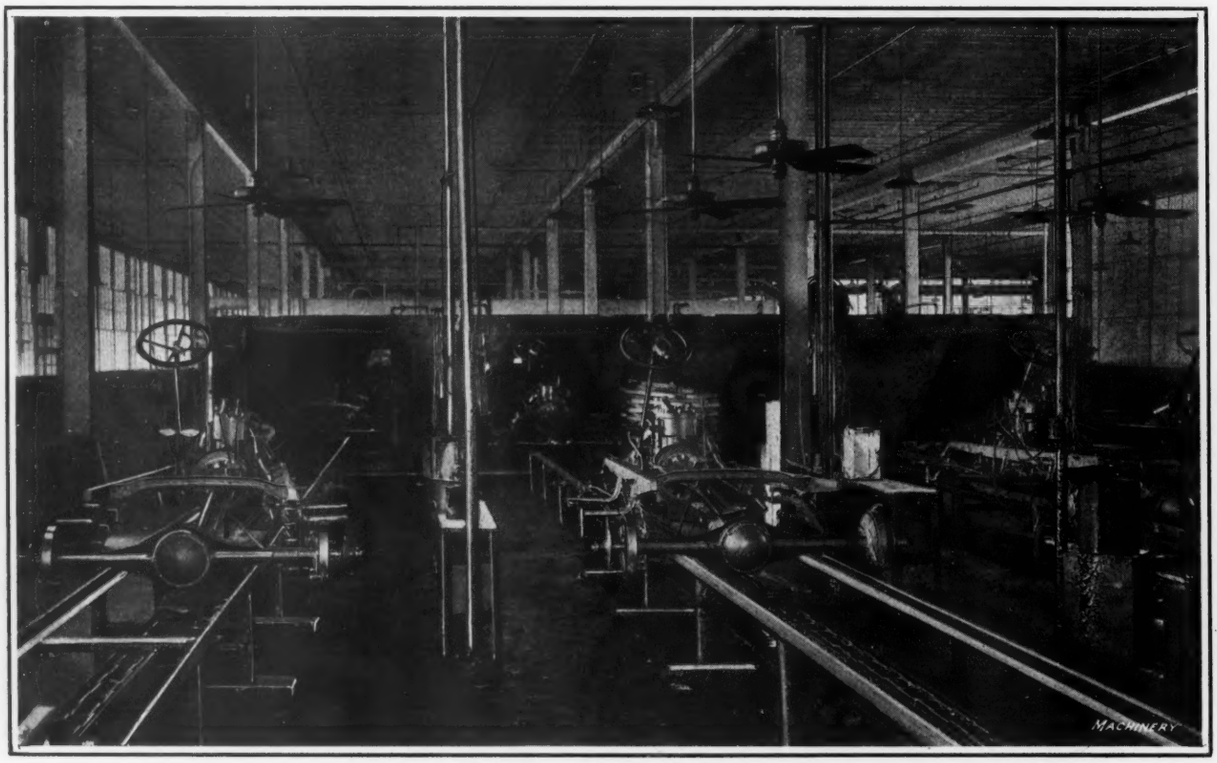


Fig. 15. The Chassis are painted as they pass along the Main Assembling Lines. At the Point shown, Paint is applied and as the Conveyors carry the Work through the Ovens, the Paint is baked to avoid Loss of Time in drying

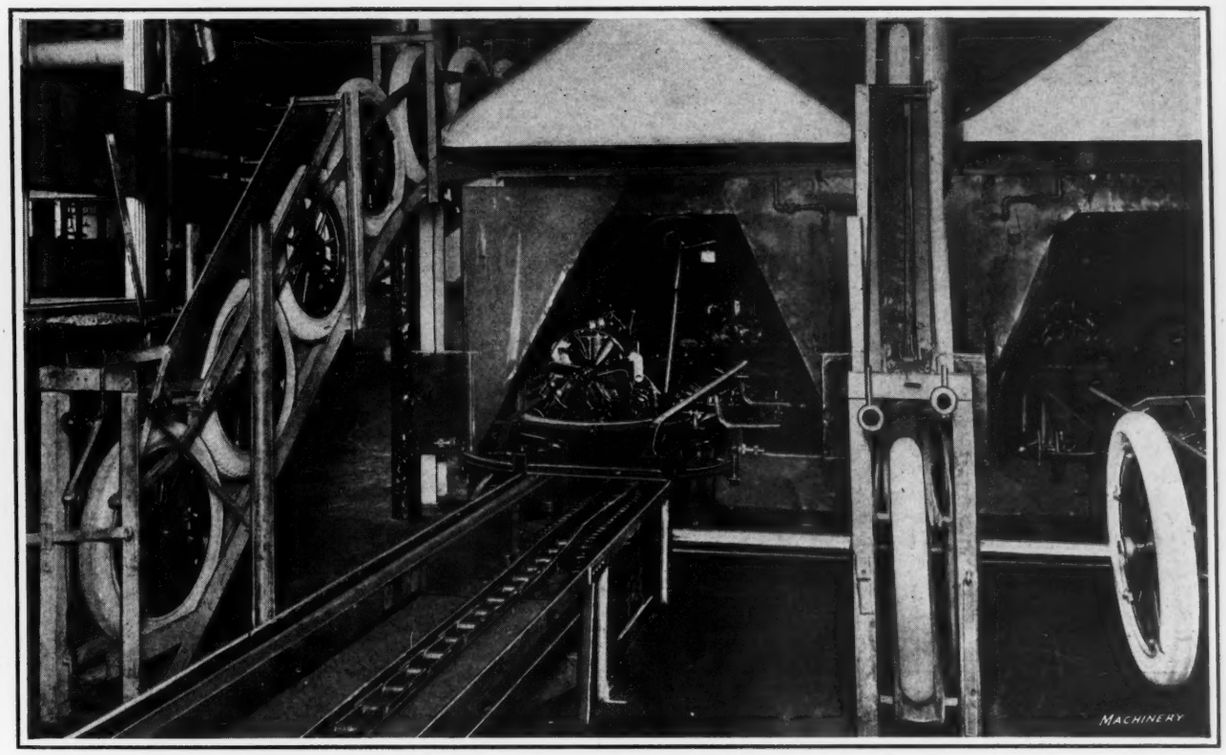


Fig. 16. Opposite End of Drying Oven shown in Fig. 15. The Work is cooled at this Point by Blasts of Cold Air. The Wheels shown in this Illustration descend from the Storage Space to which they are delivered by a Conveyor

various parts of the work of assembling, so that they are able to give efficient service in the performance of a number of these highly specialized tasks without delaying production.

Advantages of the Method of Progressive Assembly

It is coming to be generally recognized by progressive manufacturers that there are few methods which are capable of effecting greater savings in production costs than a properly worked out application of the method of progressive assembly. Although this method was originated in the automobile industry, its field of usefulness is by no means restricted to plants engaged in the production of motor cars. For these reasons, it may be well to call attention at this point to a modification of the power-driven assembling conveyor which has been found to give satisfactory results in several plants. Instead of having the conveyor moving continuously at a predetermined speed, this modification, to which reference is made, consists of having a control station at the end of the assembling line, where means are provided for starting the conveyor to advance all of the work on the assembling line to the next station, after which the conveyor is stopped long enough to allow the next assembling operation to be performed.

As rapidly as the men at each station complete their work, a signal button is pushed, causing a light to flash under a number designating that station on an indicator board, which forms part of the equipment of the control station. As soon as all of these lights have been turned on, it indicates to the man in charge of the control station that the work of

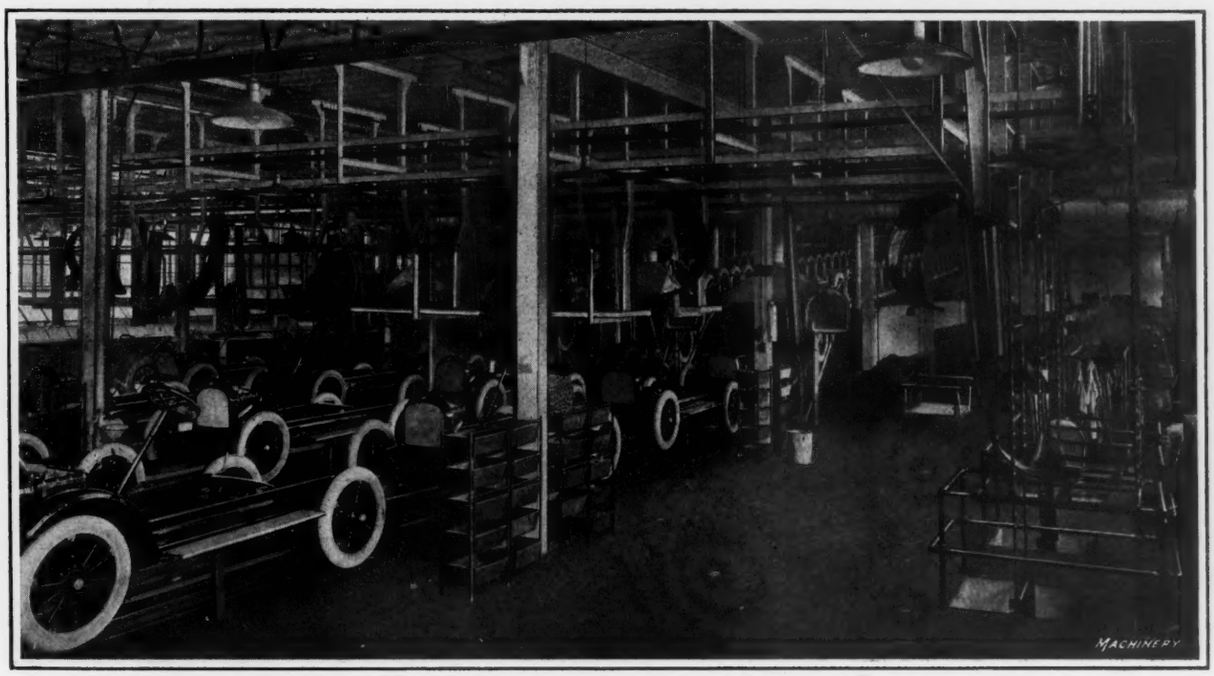


Fig. 17. Passing Transversely across the Four Main Assembling Lines there are Overhead Conveyors that carry a Continuous Stream of Fenders, Running Boards, Radiators, and other Auxiliary Parts to the Men who assemble them on the Cars

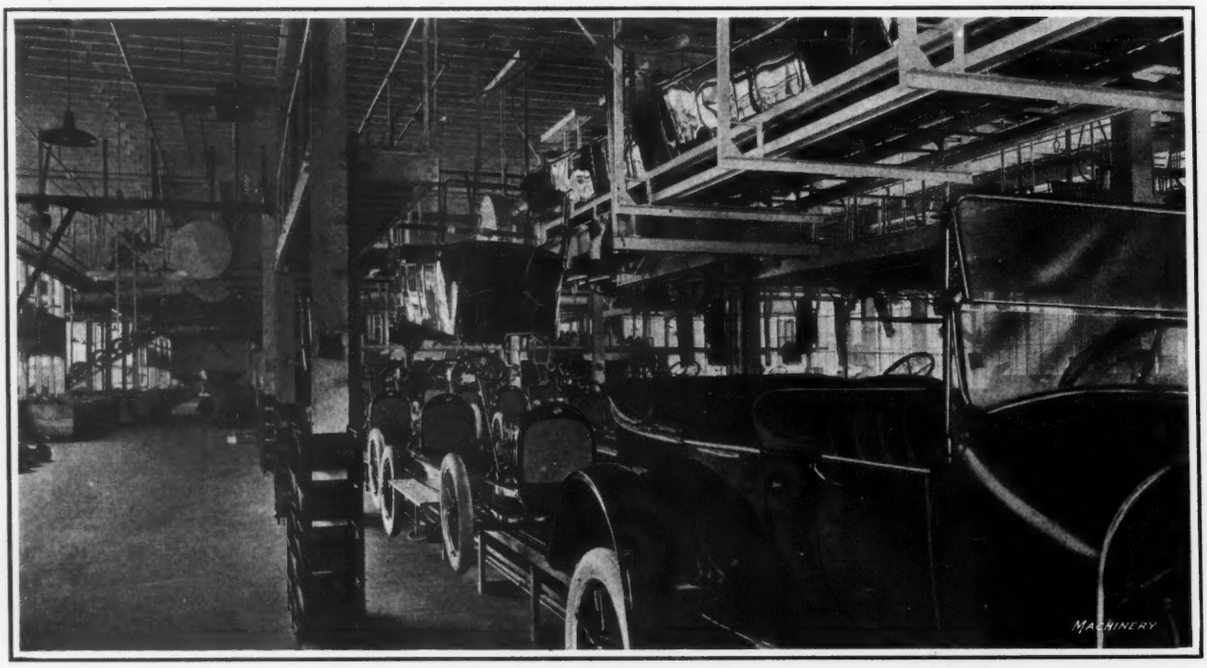


Fig. 18. Assembled Bodies are lowered through the Floor above to the Overhead Conveyor here shown, and carried to a Point over the Four Main Assembling Lines at which the Bodies are assembled on the Chassis

assembling has been completed at every station along the line; and immediately the last signal light appears, he throws over the control lever to move the conveyor sufficiently to advance the work to the next assembling station. A careful record is kept of the order in which each station along the assembling line completes its work. This is an important source of information for the production department, as a study of this record will sometimes show that one station along the line is consistently the last in finishing its work. When the records reveal such a condition, an investigation is immediately started to ascertain whether the men employed at that station are taking too much time over their work, or whether they have too much work to do in a specified time. In either case, the necessary correction will be made to enable this assembling station to complete its work with the required degree of rapidity.

At the Willys-Overland plant in Toledo, the chassis frames are stored in the basement, and delivery is made from this storage space to the starting point of the main assembling line by means of a conveyor system as shown in Fig. 12. It will be seen that this consists of two T-irons on the edges of which the chassis slides. There are hooks on the power-driven Link-Belt chain which provides the source of motive power, these hooks being so arranged that they grip a chassis when it is placed upon the conveyor rails, without requiring any attention from the workmen. Several drilling

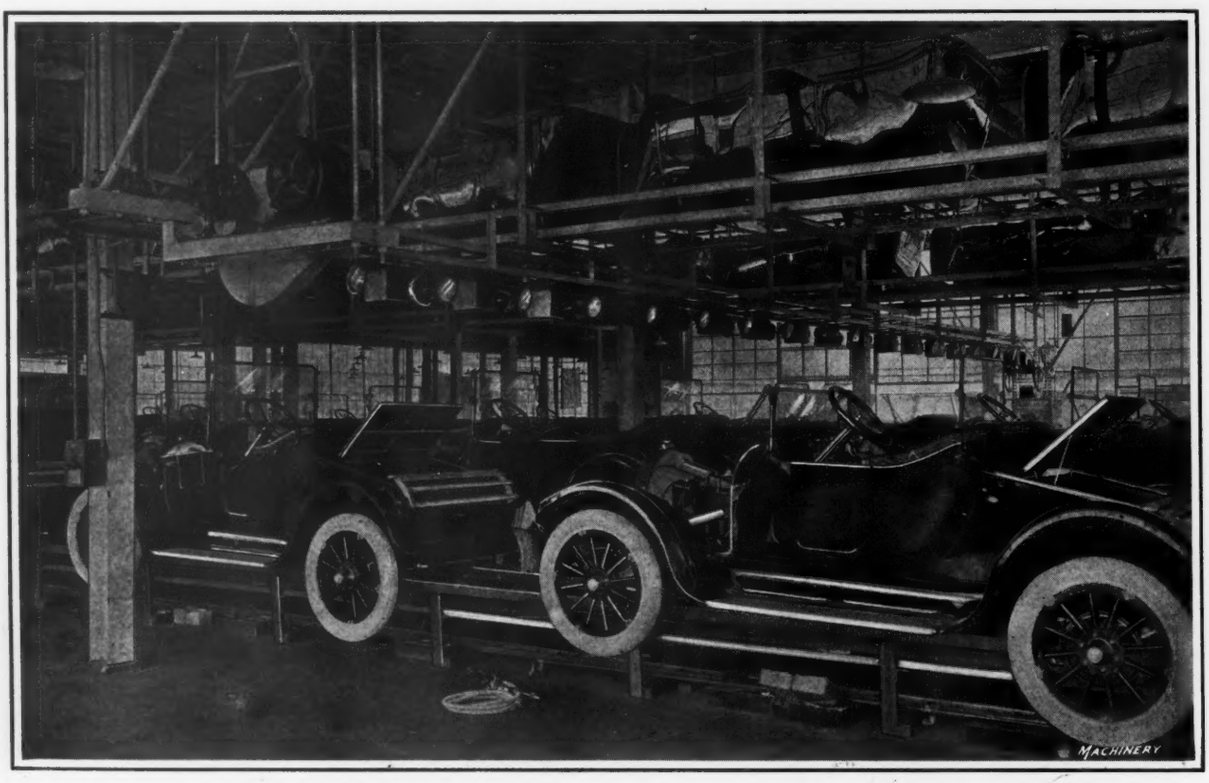


Fig. 19. View of Four Main Assembling Lines where the Work is still further advanced. This Illustration shows Overhead Conveyors carrying Lamps to be assembled on the Cars

operations and similar work is done on the chassis as they are carried along by the conveyor. In the background of this illustration it will be seen that the conveyor track runs up at an angle to carry the work through an opening to the first floor of the plant, on which the main assembling lines are located, the upper end of the chassis conveyor being shown at the left-hand side of Fig. 13. It will be apparent from this illustration that each chassis is delivered from this conveyor to a receiving platform, from which it is slid to a hand truck on which it is pushed across to the starting point of either of four assembling lines, each parallel to the other. As each chassis is pushed off the truck on the assembling track, the rear axle is fastened to the rear springs. Fig. 6, in the September number, showed the apron conveyor which carries the completely assembled engines through a tunnel to the central storage space. From the point where this apron conveyor discharges its load, an overhead conveyor picks up the engines and carries them to a position above the four main assembling tracks, where they are lowered within reach of the men who bolt the engines to the chassis frames. Fig. 14 shows the chassis with the engine in place. From this point onward, the various parts, such as steering wheels, motor controls, fans, lamps, etc., are brought to successive positions over the four main assembling lines, ready to be attached to the cars. Reference to the remaining illustrations will show the car in the various stages of completion, and give a representative idea of the way in which it grows from a bare chassis frame to the complete car that runs off the end of the assembling track under its own power.

When the partial assembly of a Willys-Overland car has reached the stage of development shown in Fig. 15, it is ready to be painted, and in order that this part of the work may be accomplished as rapidly as possible, a practice is made of spraying the paint on those parts which require protection against damage from rust. The paint is sprayed on while the chassis passes over a draining pit that will be seen under each of the four assembling tracks, after which the partial assembly passes on through a drying oven, which hardens the paint sufficiently so that the work of assembling can proceed immediately after each chassis emerges from the opposite end of the drying oven. However, it is necessary to cool the work sufficiently so that it can be handled, and this is done by means of blasts of cold air that are directed on the chassis as they leave the ovens. In Fig. 16 there is shown a view of the assembling tracks coming out at the opposite ends of the ovens, which are shown in the preceding illustration; and leading down from a storage space located above these ovens will be seen tracks which carry a continuous stream of assembled wheels.

In the condition in which the work is shown in Fig. 17, these wheels have been assembled on the axles, and the work has progressed from the drying ovens to a point at which the fenders are secured in place. Coming up through the floor at the right-hand side of this picture there will be seen three elevating conveyors which carry up the fenders, running boards, mud guards and radiators, and transfer them over the four assembling tracks, so that the men employed to bolt these parts in place are kept constantly supplied with the parts which are required for their work. By carefully synchronizing the relative speeds of the four main assembling lines and the elevating conveyors, no trouble is experienced through having a surplus of parts, or through failure of parts to reach the assemblers as rapidly as they are needed. This system of using cross-conveyors to bring work to the four main assembling lines, makes it unnecessary to resort to either of the objectionable practices of carrying the material on trucks or of storing a surplus supply on the assembling floor.

In connection with the description of the method of procedure in handling the work of the body department (Figs. 7 and 8 in the September number), mention was made of the fact that this section of the plant is located on the second floor, and that finished bodies are lowered through an opening in the floor to an overhead conveyor, which carries them to the four main assembling lines. A view of this overhead conveyor is shown in Fig. 18, which also includes the trolley hoist that is used to take bodies from the conveyor and lower them into place on the chassis, as they travel along the four assembling lines. In the background,

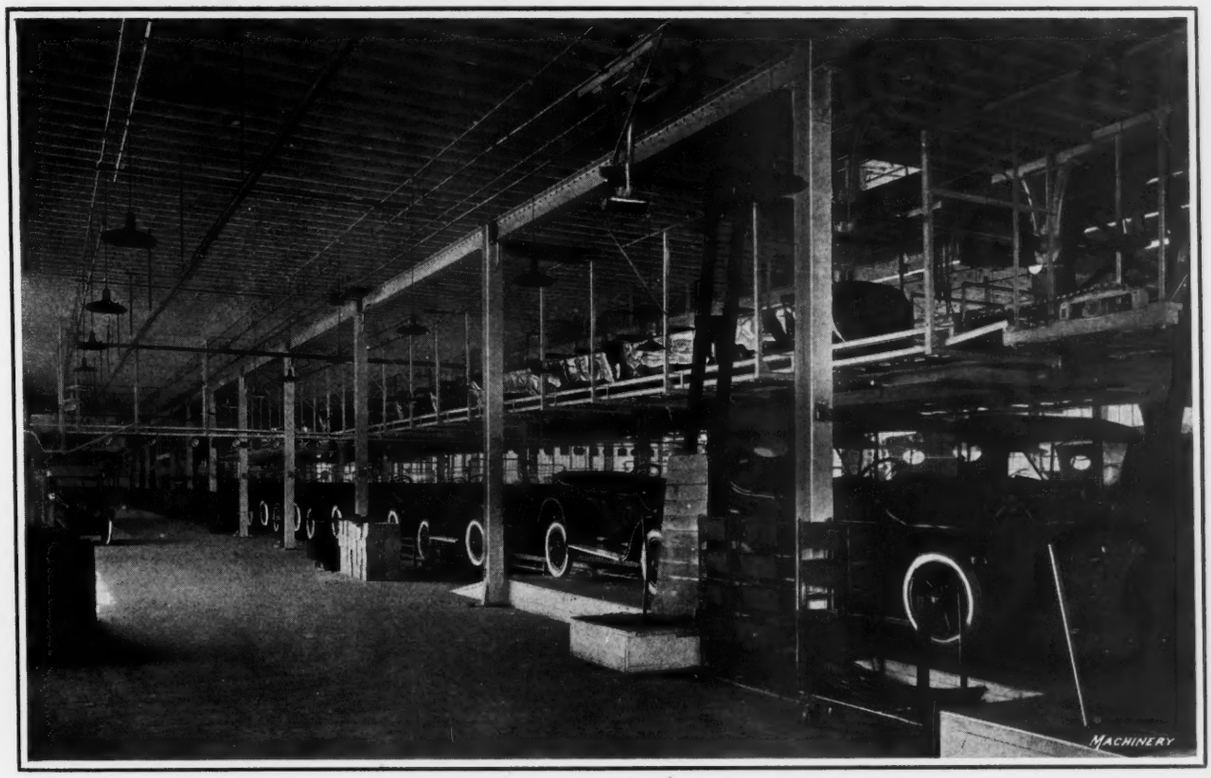


Fig. 20. At this Point, Cars carried on the Assembling Lines receive a Preliminary Running Test to "limber" up the Engine. The Back Wheels run on Idler Rollers mounted beneath the Floor

at the left-hand side of this illustration, there will be seen the conveyor line which carries the assembled wheels up to the storage space above the drying ovens; and another view of the fender, running board, and radiator conveyor which serves the four main assembling tracks will also be seen at the extreme right. Fig. 19 shows cars on the assembling track after the bodies have been mounted in place, and at the point at which this picture was taken, there is located a cross-conveyor that carries lamps, batteries, horns, etc., up from the storage space in the basement and over the four assembling lines ready for the men whose duty it is to mount them on the partially finished machines.

During the process of assembling the Willys-Overland cars, a gasoline tank is delivered to the assembling line containing a sufficient supply of fuel to provide for giving the car a brief running test before it leaves the assembling line, and then sending it away from the end of the line under the power of its own engine. In Fig. 20 there is shown a platform on which the engine and transmission of each car is "limbered" up before the finished car leaves the assembling department. For this purpose it will be seen that the floor is raised at the point where the cars, which were formerly carried by the conveyor with their wheels lifted clear of the floor, are run off the assembling track. Beneath the platform, or raised portion of the floor, there are freely mounted rollers on which the rear or driving wheels are located, after which the engine is started so that the driving wheels may rotate without exerting any tendency to advance the car. During the time that the engine is getting this preliminary running test, the assemblers busy themselves in mounting the cover on the body of the car; and after this work has been accomplished, the machine is driven away, ready for the final running test before shipment. The final illustration, Fig. 21, shows a view taken at the end of the assembling line just as the finished cars are ready to leave.

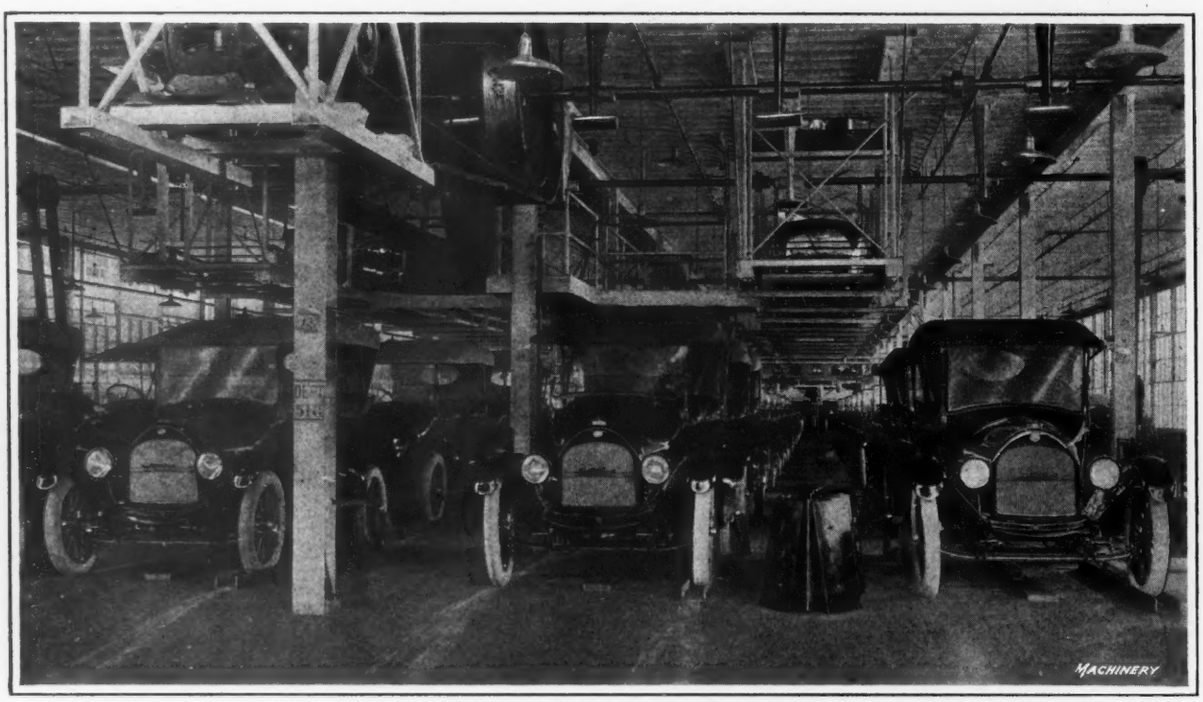


Fig. 21. The Gasoline Tank which is assembled on Each Car contains a Sufficient Supply of Fuel so that when the Finished Car reaches the End of the Line, it may run off under its Own Power

* * *

Commenting on reports that American-made steel is heavily underbidding British steel in English markets, the counsel for the National Erectors' Association (United States) says that since wages in England are still substantially below those of this country, the real differential which explains our cheaper production cost must be found in the lesser output of the English worker under his union rules.

HOURS OF WORK AS RELATED TO OUTPUT AND HEALTH OF WORKERS

The National Industrial Conference Board, Boston, Mass., has issued a comprehensive report on hours of work as related to output and health of workers, this report relating to the metal manufacturing industries. The investigation upon which this report is based justifies the conclusion that a considerable proportion of metal-working establishments is able to maintain production on a schedule of fifty hours per week, but that such schedule could not be universally adopted by the metal-working industry without some loss in production. In the case of a forty-eight-hour week a smaller proportion of establishments report production as being maintained, but the conclusion of the report states that the weight of the evidence leaves little ground for doubt that the general reduction to a forty-eight-hour week at the present time would mean a serious loss in production. In plants where a very large percentage of the work is performed by automatic machinery, the evidence indicates that, in general, maximum production cannot be obtained on a schedule as low as forty-eight or fifty hours per week. The investigation states that there has been no significant change in the health of metal workers resulting from reduction in working hours.

The report points out the distinction which should be made between what *can* be done in fifty hours and what, as a matter of record, *is* done. If both management and workers would actively cooperate, a forty-eight-hour week might prove practicable in a larger number of establishments than is now the case, but unless such cooperation is secured there can be little question that the general adoption of the forty-eight-hour week in the metal trades would involve a serious economic loss to the nation. If workers would realize, says the report, the indisputable principle that their real interest and their real opportunity for bettering their condition lies in increasing the efficiency of individual production, a great deal would be gained.

The conclusions drawn in the report are based upon an investigation made by sending out two questionnaires to which replies were received from 1252 establishments employing 753,561 workers. Of these, 413 establishments employing 358,336 workers had reduced the hours.

Purpose of Models in Interchangeable Manufacturing

By EARLE BUCKINGHAM, Engineer, Pratt & Whitney Co., Hartford, Conn.

The increase in general mechanical knowledge and the improvements in the language of drawings have, in many cases, rendered the making of models unnecessary, but conditions still exist where their use results in the economical solution of many manufacturing problems. The object of this article is to point out this limited use and to indicate their relative position in the constructive development of a new commodity, which is to be manufactured in large quantities by the use of interchangeable methods.

A MODEL mechanism, constructed personally by the inventor, or by the workmen under his immediate direction, was the original form of making and recording a new design. The introduction and development of mechanical drawings superseded many of the functions previously performed by the model. At the present time, therefore, the practice of developing models has been relegated to a comparatively insignificant place in most lines of manufacturing. They are still employed to a limited degree, however, by several manufacturers for a variety of purposes.

The primary purpose of any model at the present time is to prove—not to originate—a new or improved design that has been developed only on paper. It may be either to prove the possibility of the functional design or to check the manufacturing design. This may be done by a single mechanism in some cases, or several duplicate mechanisms may be required to prove its operation under various service conditions.

Manufacturing models may be used for one or more of the following purposes: First, to check the operation of the manufacturing design against the experimental model; second, to prove the manufacturing design in regard to the service requirements; third, to test the manufacturing tolerances which may be contemplated; and fourth, to create a physical standard of precision for future manufacturing.

Manufacturing Model to Test Functioning

A manufacturing model used to test the functioning of the manufacturing design is merely a sample mechanism constructed in the tool-room or machine shop to detect as many faults as possible in the design or to discover possible errors in the component drawings. It is essentially a precautionary measure. It is more economical to detect and correct a fault on one sample than it is to salvage a large number of parts after production is started, with the additional expense of correcting the manufacturing equipment. After such a model has demonstrated the success of the manufacturing design and the correctness of the component drawings, its purpose has been achieved. Its future disposition is a matter of little moment.

Such a model is seldom necessary on simple mechanisms that are merely new combinations of old and proved mechanical movements, or on minor variations of proved designs, such as standard motors, dynamos, various types of engines, and many machine tools. The actions of such mechanisms under many conditions have been so well established that practically all of the necessary experimental work can be accomplished on paper. On many other mechanisms, however, such as typewriters, adding machines, small arms, watches, etc., the mechanical movements of which are delicate and intricate and not so positive, manufacturing models are a vital necessity. In general, such a model will be constructed when the insurance against the possible errors in the design is worth the expense entailed. For this reason it is often customary to first build a pilot machine before putting through a lot of new or special machines.

If a new commodity is designed, particularly if it is to fill a new demand, it is advisable to determine its action in actual service before extensive productive operations are far advanced. The only sure method of obtaining this information is to have one or more mechanisms built and operated under the conditions with which they are expected to contend. The manufacturing model, which is built to test the manufacturing design, is often used for this purpose. As a matter of fact, the test for functioning should also include the tests for service requirements, inasmuch as this factor of functioning should include the measure of service which the mechanism must render throughout its normal life.

For example, a large plant in the Middle West goes thoroughly into this preliminary work on all new models. Three successive designs are developed and tested. First, the functional or inventive design is made and tested. Second, the manufacturing design is carefully developed and tested by means of a manufacturing model. When this last design seems satisfactory, it is turned over to the tool designing department which goes over it a third time solely to simplify the tooling and mechanical productive operations. The changes made at this time, however, affect minor details only. From twenty-five to fifty mechanisms are built to this design and sent into the field for actual service. These last models must give satisfactory service for from one to two years before further preparations for manufacture are considered. It is of interest to note that the manufacturing equipment provided by this factory is very complete; also that changes here in the process of manufacture or in the product under production are very rare.

Many of the so-called improvements in new commodities which result in frequent modifications of the product under manufacture are only steps taken to correct mistakes, omissions, and other faults due in large measure to neglect of the manufacturing design (both neglect to make and neglect to test it) because of haste to rush into actual production. This has been forcibly brought out by the conditions which developed in the manufacture of many devices during the war.

Models to Test the Tolerances

It is desirable to know at the earliest possible moment whether or not the specified tolerances define the limits of parts that will function properly. The sooner this information is obtained, the sooner we can concentrate our efforts on problems of production alone. Until this matter is settled within a reasonable degree of certainty, each problem in production is complicated by many considerations relating to the design and tolerances. This causes innumerable revisions on the component drawings with the attendant changes in tools, fixtures, and gages, resulting in delays in production and additional expense.

Some concerns try to solve this problem by carefully building several models which represent as closely as practicable the extreme conditions permitted by the component drawings. These model parts are assembled and reassembled,

and tested for operation after each assembly. Necessary alterations of the drawings are made before manufacturing operations are under way. This practice is, naturally, very expensive, as each of these models costs much more to construct than any of the preceding ones. However, if insurance against future changes is worth the expense, the practice is well worth while.

One typewriter manufacturer makes a practice of building from six to ten sets of model parts before any new or revised machine is manufactured. When only one unit assembly is affected, model parts for that mechanism only are made. These parts are then sent to the assembling department for trial. Except on purely experimental models, the men who make the parts are not allowed to assemble them. No effort is made to do anything more than to duplicate the kind of work normally produced in the manufacturing departments. The parts are not cornered nor burred unless that operation is required in manufacture. In other words, the attempt is made to determine how little effort will be required to manufacture the mechanism satisfactorily. The sizes of these parts usually cover the entire range between the specified limits, but no distinct effort is made to have them meet either limit exactly. Any combination of these parts must assemble and operate properly before changes or new models are adopted. This practice has saved the company several times from making unnecessary and improper changes.

Model for Standard of Precision

The component drawings give many dimensions. Strictly speaking, the expressed dimensions represent absolute sizes. Dimensions of elementary surfaces can be produced and reproduced within relatively small limits of error. Often, however, these dimensions define developed and complicated profiles, locations, and other composite surfaces which cannot be reproduced as readily. Yet, they must be reproduced many times over in the course of manufacture to within relatively small limits of error.

We must choose between accuracy and precision at the outset. In the case of elementary surfaces, accuracy is usually the better choice; but for many composite surfaces, precision will often give the quicker, more economical, and more practical results. On the other hand, it must be clearly understood that when precision is choosen, it becomes practically impossible for another plant, working in entire independence of the first, to produce a common interchangeable product. If more than one plant is engaged on the production, they must maintain close relations in almost every detail of the work. In order to maintain this precision within reasonably close limits, physical standards of some sort must be provided at the very beginning. By developing a model for this purpose, two results can be accomplished at the same time. Such a model will test the manufacturing design for functioning, and will also provide the desired physical standards.

This model must be made with the greatest care and should represent the "danger zone"—that is, in most cases, the maximum metal or minimum clearance conditions. It is evident that these sizes are the most important. They control the interchangeability. No cuts, other than slight cornering and similar burring operations, should be made with a hand tool, such as a file. Whenever the contour of the surface in question is important, templets should be made to check the special tools used. These templets are an integral part of the model. All important locations of holes should be established from master plates. Templets, master plates, etc., as well as the model parts, are invaluable when the equipment is built; properly utilized, they will insure a high degree of uniformity at relatively small expense. Such a model must be used with the greatest care and becomes the court of last appeal in many of the perplexing questions which inevitably arise in the manufacturing departments of a plant engaged in producing an interchangeable product in large quantities.

This practice in regard to models is extensively followed in the manufacture of small arms. As stated before, it has a certain disadvantage when more than one factory is involved. As it is impossible to duplicate the model exactly, one of two courses is open. Either one model is standard for all plants—which entails much lost time in referring many detailed questions back to the central plant—or additional models may be made, which results in different basic standards at the various plants. If the second course is followed, and all parts of all models are mutually interchangeable, the product of the various factories will be interchangeable. However, this results in reducing the amount of the absolute tolerances available for manufacturing variations, as the variations in the different models consume a certain amount. In cases where the functional conditions are exacting, this method is often found impracticable. On the other hand, if the design of the mechanism is such that the absolute tolerances are liberal, the second method gives an economical solution.

All the foregoing model work, regardless of its purpose, is essentially a preliminary measure in the manufacture of a new or revised product. Properly conducted, it will stabilize the manufacturing design at a minimum expense. It takes considerable time, however, and that is one reason why models are not more extensively employed. For any commodity that is already under manufacture and the design of which is already standardized, models are of doubtful value.

* * *

OXY-ACETYLENE CUTTING

The oxy-acetylene cutting process was of vital importance during the war period in speeding up production. Several applications of the process are cited in a paper by R. R. Browning, vice-president of the Oxweld Acetylene Co., Chicago, Ill., which was presented at the annual convention of the International Acetylene Association. Two of the several interesting uses mentioned are the cutting of port-holes and the removing of extra metal from naval and field gun slides.

It has always been customary in shipyards to punch a large number of holes with a ½- or ¾-inch punch around the periphery of the proposed port-hole. The central portion, or plate, is removed in this manner, the edges then being trimmed by means of a chipping hammer. An average of 1½ hours was required to make a 12-inch port-hole by this method, whereas with an oxy-acetylene cutting blowpipe and a simple attachment, the port-holes were completed in an average time of five minutes each. This not only shows a considerable saving in time in doing the work, but it can also be said that the finished port-hole, when made by the oxy-acetylene cutting process, has a better appearance than results from the use of the older process.

Shortly after the United States entered the war, contracts were placed with numerous steel foundries throughout the country for castings to be used in the construction of naval and field guns. One of these castings, the gun slide, is very difficult to manufacture. It has a trunnion or projection of metal on each side, which is very heavy compared to the walls of the casting, and in order to eliminate shrinkage and cracking when the casting cools, the trunnion has to be carried clear across the casting. After the casting is cooled, part of the trunnion has to be removed. To remove this part by machining would be very slow and costly; hence a number of foundries used the oxy-acetylene cutting blowpipe for removing the surplus metal. The time saving, as compared with older methods, was an important factor in the speed of production.

* * *

Belgian reconstruction is proceeding rapidly in all the industries, as evidenced by the large amount of imports of machine tools and machinery of all kinds into that country. It has been decided to hold a national industry exhibition in Brussels in April, 1920. To what extent foreign exhibitors will be invited to exhibit has not yet been announced.

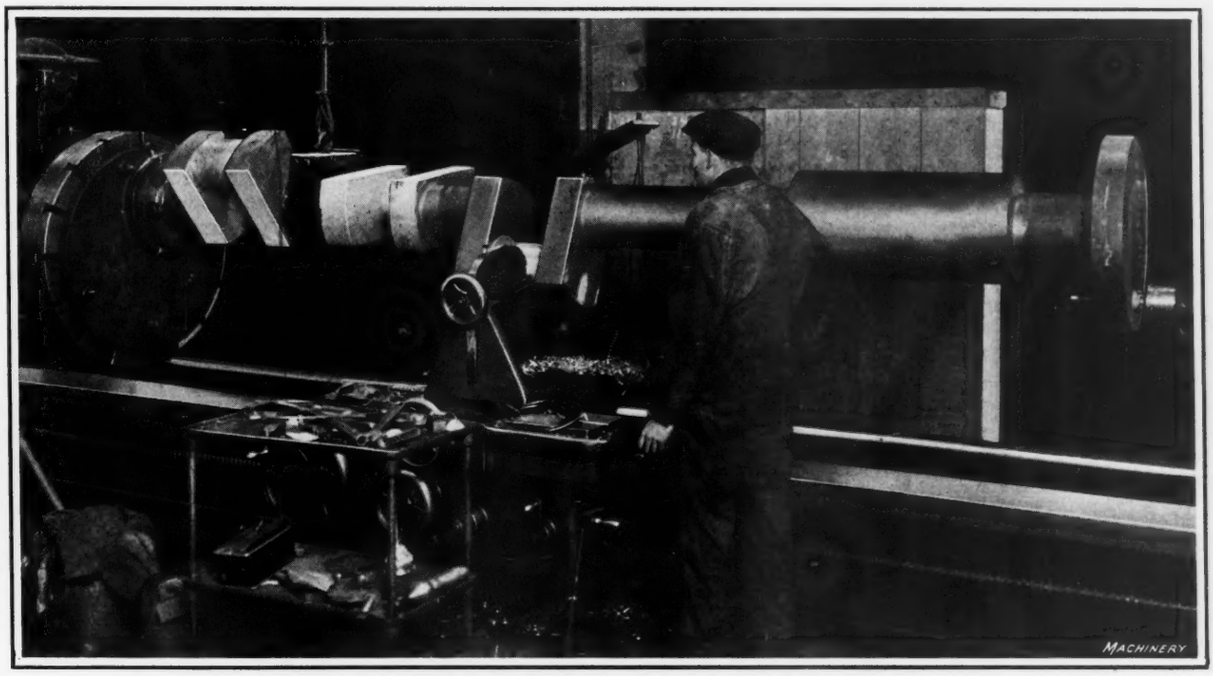


Fig. 1. Turning the Crankpins. Note the Special Design of Tool Support used

Turning a Marine Engine Crankshaft

THE turning of a crankshaft for a 500-horsepower, six-cylinder marine engine is shown in Figs. 1 and 2, which illustrate how this work is done at the Skandia Pacific Oil Engine Co., Oakland, Cal. The turning of a crankpin is illustrated in Fig. 1, which shows two interesting features of this work, namely, the special form of tool support used and the method of counterbalancing the crankshaft while the crankpins are being turned.

The tool-holder is designed to grip the tool and provide a solid unyielding support, but it has the advantage of being very narrow and does not interfere with the rotating webs of the crank. A detailed view of this tool-holder is shown in Fig. 3. The base is a heavy casting which is fitted to the ways of the carriage in place of the cross-slide. A flat steel plate about 1½ inch thick is fitted and securely clamped to this base casting. This flat plate has a notch or opening near the upper end for receiving the turning tool. Just above the tool there is a wedge-shaped clamp which is drawn back by means of a screw connecting with the handwheel seen at the front of the tool-holder. The tool itself is provided with a groove which engages a tongue on the lower side of the notch formed in the tool plate. The rear end of the tool also has an adjustable backing screw. With this arrangement, the tool is securely supported against endwise, lateral, and downward thrusts, and the tool-holding plate is so narrow that it occupies little room between the webs.

This six-throw crankshaft is formed of two sections of three throws each. These sections are flanged and bolted together and one is provided with thrust collars for the regular type of thrust bearing. Fig. 1 shows one of the sections in the lathe. The crankpins are located 120 degrees apart and each pin is aligned with the axis of the lathe by changing the position of the shaft relative to the special faceplate casting and by changing the position of the tailstock center. Three centers 120 degrees apart are formed in a ring that is bolted to the flange at the tailstock end of the crankshaft. At the opposite end the flange fits into a circular recess, the center of which is offset relative to the

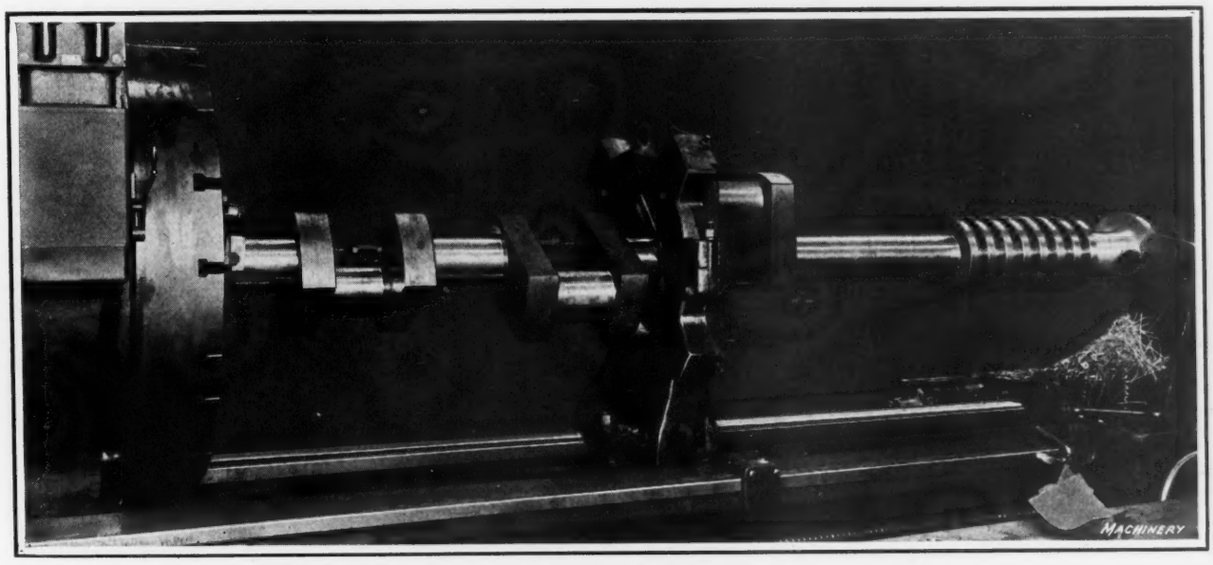


Fig. 2. Finishing the Journals after completing the Turning Operations on the Crankpins

axis of the lathe spindle a distance equal to the throw of the crank.

The counterbalancing of the crankshaft is effected by means of an ingenious, but simple, device consisting of a steel strap which surrounds one of the journals, as shown in Fig. 1, and is attached to a steel cable which passes over a pulley above the lathe to a counterweight attached to the opposite end. With this arrangement, when the unbalanced part of the crankshaft is revolving in an upward direction, the strap and counterweight assist in this upward movement. On the contrary, when the unbalanced mass is descending, it is supported by the counterweight. It will be seen, therefore, that the effect is similar to that obtained when weights are attached to the faceplate on the side opposite the heavy unbalanced sections. The advantage of using a strap and counterweight attached to a cable is that the counterbalancing can be applied at a point that is at least approximately in the center of the unbalanced mass instead of at one end; consequently the shaft not only is counterbalanced, but its tendency to sag is also overcome.

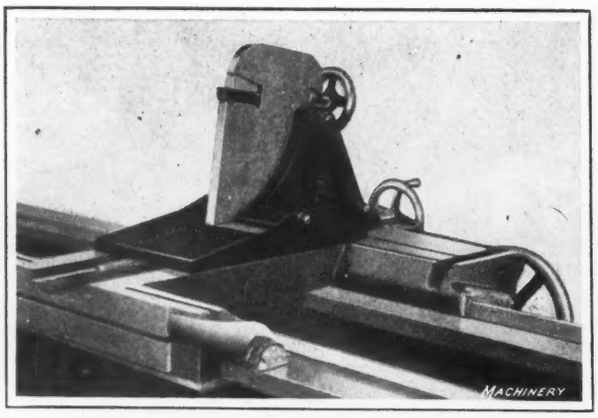


Fig. 3. Special Form of Tool-holder used for turning Crankshafts

Fig. 2 shows the crankshaft in position for finishing the journals. The center of the shaft is supported by means of a heavy steadyrest. The practice in machining these shafts is to first rough-turn the journals, then finish the crankpins complete, and finally place the crankshaft back on the main centers for finishing the journals to size. This method insures accuracy of alignment. These shafts measure 15 feet 6 inches over-all, and the journals and crankpins are 8½ inches in diameter. Each crankshaft section is forged from a solid billet of open-hearth steel. All important dimensions are said to be held within a tolerance of 0.0005 inch. The Houston, Stanwood & Gamble Co.'s lathes are used.

* * *

RECLAIMING WASTE AND OIL

By J. EMILE COLEMAN

A certain plant which uses approximately 19,000 pounds of waste yearly has installed an oil and waste reclaiming outfit, a description of which may be helpful to others. A large part of the waste is used in the milling machine and screw machine departments. This waste becomes saturated with expensive cutting oil and contains many sharp metal chips. At least 4000 pounds of waste are used in the paint shop each year, although no attempt to reclaim this has been made.

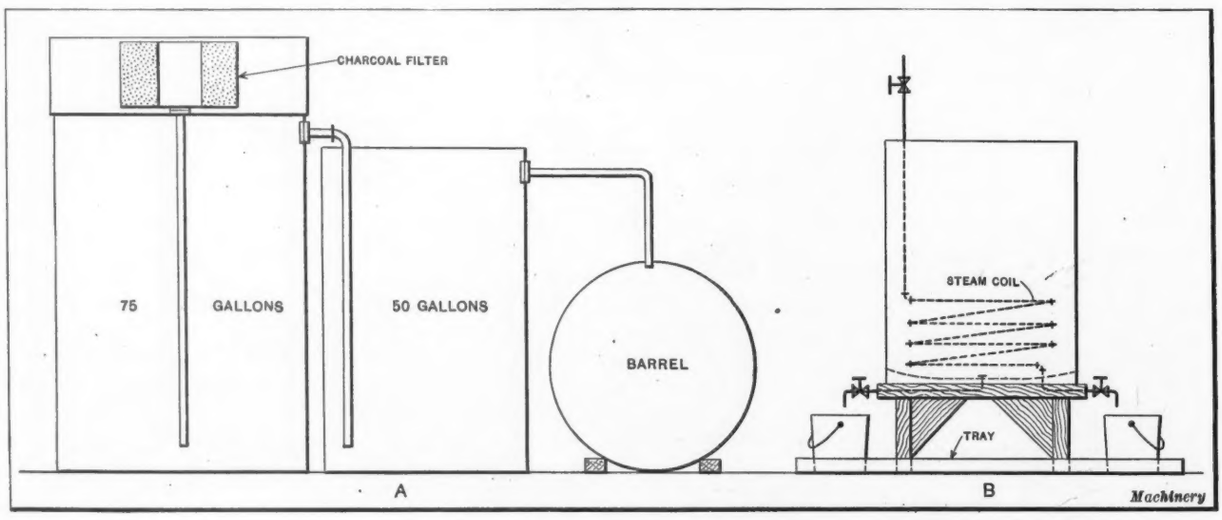
The outfit consists of a steam turbine-driven centrifugal machine in which, after being charged with waste, four operations are performed. First, the oil is extracted by centrifugal force, aided by the exhaust steam from the turbine. Second, the waste is washed in boiling water which contains washing powder. The third operation consists of rinsing the waste in fresh water, and finally the machine acts as a centrifugal drier. The apparatus was installed on the top floor of a five-story frame building, and had only a light wooden framework for a foundation. This location was tentatively chosen, because of available steam, water, and sewer connections. The machine is still operating there, however.

A steam pressure of 50 pounds gage is required to drive the turbine. The first trouble experienced arose from the excessive pressure drop, due to the long line of small piping from the boiler to the machine. As the line is fed from higher steam pressure through a reducing valve, this difficulty was easily overcome by increasing the pressure on the line. The next difficulty was due to small pieces of waste clogging the globe valves in the sewer pipe connection. The globe valves were then replaced by gate valves.

After being removed from the machine, the waste is spread out to dry, in layers about 4 inches deep on old iron window gratings. The gratings are raised from the floor so that the air is free to circulate under the waste. After it has become thoroughly dry, the loose dirt and chips are shaken out by hand, and any waste containing chips that cannot be easily removed is discarded. This loss does not amount to more than 5 per cent.

Reclaiming the Extracted Cutting Oil

Reclaiming the extracted oil was a more difficult process because the lard oil component emulsifies with the condensed steam during the extracting process. After standing for more than two weeks, even the oil from near the top of the container could not be used for cutting purposes. After experimenting, it was decided to give the emulsion a heat-treatment which would refine the oil. In the illustration at *B*, the arrangement used for accomplishing this purpose is shown. It consists of a galvanized iron barrel equipped with a steam coil made of ½-inch pipe and elbows. A drain



Equipment employed in refining Reclaimed Oil

pipe was tapped in at the lowest part of the slightly concave bottom of the barrel and the outside and bottom were covered with hair felt. The tank was then placed on a stand in a galvanized iron tray, high enough so that a pail could be placed under the drain pipe to catch the drip from the steam coil. The drain pipe was brought out beyond the side of the tank and provided with a gate valve. It was found that by slowly boiling the emulsion, the danger of boiling over was reduced, and disagreeable fumes were practically eliminated. Most of the water as it separates from the oil, collects at the bottom of the tank and is withdrawn from time to time through the drain pipe.

After boiling, the oil is put through a charcoal filter. It was found, however, that even then the oil contained too much water to be satisfactorily used as a cutting oil, but after standing in a tank for nearly a month, tests showed that no water existed in the mixture near the top of the tank, also that the composition of the oil at both the top and bottom of the tank was practically the same, and that the oil contained on inorganic matter. The arrangement shown at *A* in the illustration was consequently adopted for further treating the oil.

It consists of two galvanized iron tanks, one of 75 gallons and the other of 50 gallons capacity. A charcoal filter was made to fit the larger tank as a cover. The oil flows from the filter to the bottom of this tank through a pipe and from near the top of the tank it overflows through another pipe and is carried to the bottom of the smaller tank. From this tank, it again overflows through a pipe into a barrel. When the barrel is full, it is sent to the machine shop and another barrel put in its place. The oil thus treated has proved perfectly satisfactory for use as a cutting oil.

The Economical Value of the Process

During the first year of operation, 2700 pounds of waste and 230 gallons of oil were reclaimed, the following statement being self-explanatory:

Value of new cutting oil at 80 cents per gal....		$184
Value of reclaimed waste at 14 cents per pound		378
		$562
Labor cost	427	
Cost of washing powder	41	
		$468
Balance		$ 94

Out of this balance in favor of the reclaiming process must be deducted the cost of steam, overhead, depreciation, upkeep, and the interest on the cost of the apparatus and its installation. This would probably be covered by $50. It may not be correct to allow the full value of new oil for that reclaimed, because new oil is used on the screw-cutting machines before it is used on the milling machines, while the reclaimed oil is used only on the milling machines. The reclaimed waste, however, actually replaces new waste.

Probably 60 per cent of the labor cost is consumed in shaking out the washed waste, the cost of which could probably be considerably reduced. At first much prejudice existed against reclaiming the waste at all, on account of the danger of cuts from sharp metal chips which might be contained in it. There appears, however, to be no great difficulty in eliminating the chips, although it is comparatively expensive. From the factory records, it was found that in the six months previous to obtaining the above figures, 7384 pounds of new waste and 2344 pounds of washed waste had been used, from which it appears that only about one-quarter of the waste used is being reclaimed, and this is washed only once.

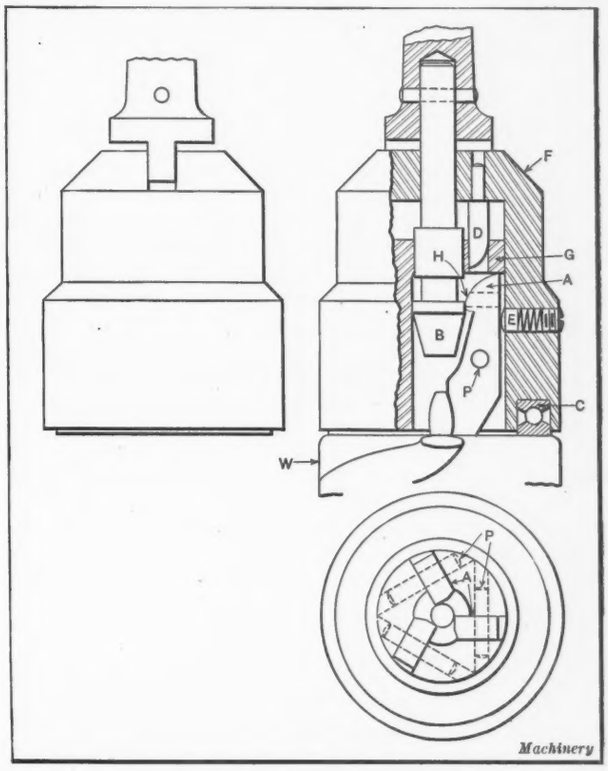
* * *

The great industrial expansion that is taking place in the United States is evidenced by the fact that new companies were formed or old companies added to their capital to the extent of $370,000,000 during the month of March, $515,000,000 during the month of April, and $750,000,000 during May.

AUTOMATIC TURNING TOOL

By O. H. KARCHER

The tool which is shown in the accompanying illustration may be used for turning small irregular shaped pieces in a drilling machine or in any other similar vertical machine. It is sometimes found impracticable to use a lathe or a turret machine for this class of work. The body *F* of the tool is bored to receive blade-holder *G*. The holder has three slots in which high-speed steel blades *A* are pivotally pinned at *P*. Plunger *B* is pinned to the shank of the tool and extends through a hole in the body *F* into a hole in the blade-holder *G*, but is not fixed to either of these parts. When in operation, the ball bearing *C* forms a support for the tool and practically eliminates the factor of friction. Before the operation starts, the blade-holder *G*, as well as the body itself, is supported by two shoulders formed on the plunger *B*.



Turning Tool for Use on Vertical Machines

As the machine spindle is lowered the body and the slotted holder are also lowered until they are stopped when the ball bearing comes into contact with the work *W*. The plunger, however, continues to descend, the tapered head coming into contact with the heel *H* of the blades and forcing the cutting ends toward the center, thus forming the work as shown.

When the plunger has forced the blades to their maximum closing position, with the heel of the blades resting on the cylindrical part of the head, as shown in the illustration, the plunger has only a slight additional distance to travel before the spring plunger *E* will force the blades against the neck of plunger *B*, thus opening the tool. The blade-holder *G* and its blades, which are now hooked over the shoulder of the tapered head, will be raised with the plunger until they come into contact with the end of pins *D*, which forces them open again against the action of the plunger *E*. This allows the plunger *B* to continue upward independently until the shoulders come into contact with the body and with holder *G*, from which point upward these two parts will also be raised with the plunger.

* * *

A South African inventor, J. Penhale, is said to have discovered a substitute for gasoline which is called "Penrol" and is obtained by absorbing pure acetylene in pure alcohol to the saturation point and adding 0.3 per cent of acrolein.

Time Slide-rules for Standard Types of Gear-cutting Machines

By S. D. G.

THE use of slide-rules and charts for determining the cutting speeds, time consumed and other data for turning, boring, drilling and planing operations is not an uncommon practice, and in most cases this method of calculating has given the desired results. Slide-rules for gear-cutters and gear shapers, however, are rarely used. One method of obtaining the desired information is to time the actual operation of the cutting of a gear, or to calculate the time from known factors by the use of a formula and the regular mathematical functions, or by the use of a formula and a standard slide-rule. It is the intention here to deal with the subject of time slide-rules for gear-cutting machinery in such a manner as will be of aid to those who regularly have need of such in their work.

Slide-rule for Fellows Gear Shaper

The time slide-rule for the Fellows gear shaper, here illustrated and described, embodies three formulas, a combination of which will give the desired result when properly applied. These three formulas give, respectively, the feeding-in time, the pitch diameter, and the cutting time. To find the total time consumed, the feeding-in time is added to the cutting time. The first formula is in the following form:

$$T_1 = \frac{W}{0.0018S} \qquad (1)$$

in which 0.0018 is the depth to which the cutter is fed per stroke of the gear shaper (constant), and

T_1 = time in minutes required to feed in to the tooth depth;
W = whole depth of tooth of gear;
S = strokes of gear shaper per minute;

The second formula used is the well-known gear formula:

$$D = \frac{N}{P} \qquad (2)$$

in which

D = pitch diameter in inches;
N = number of teeth;
P = diametral pitch.

The third formula is:

$$T_2 = \frac{XD}{S} \qquad (3)$$

in which

T_2 = time in minutes required for the blank to make one complete revolution;
X = strokes of machine per inch of pitch diameter of gear being cut;
D = pitch diameter in inches of gear being cut;
S = strokes of gear shaper per minute.

The slide-rule contains six scales, two of which D and W are on the upper part of the rule. Scale W is for the whole depth of the gear tooth and is represented by pitch numbers from 20 to 3. Since the pitch varies proportionately with the depth of tooth, this scale was made to read "pitch" instead of "tooth depth," thus making other calculations unnecessary. The scale D represents the pitch diameter of the gear in inches, and is graduated from 1 to 40 inches.

The pitch scale P on the upper side of the slide is graduated from 20 to 2 pitch, reading from the middle of the slide to the right. The other upper scale on the slide is for the strokes X of machine per inch of pitch diameter of the gear and extends from the graduation 1500 on the left to the graduation 100 in the middle. The graduations 1-F, 1-M, 1-C, 2-F, etc., on this scale are for definite strokes of the machine for 1-inch, 2-inch, etc., diameter cutters, with fine (F), medium (M), or coarse (C) feeds. This scale also shows the pointer for the feeding-in constant which is used to obtain the feeding-in time; its use will be understood later from the examples which are to follow. The lower scale of the slide is for the strokes per minute S and number of teeth N, the scale being graduated from 300 to 10.

The lower part of the rule contains one scale for both the feeding-in time and the cutting time in minutes and hours. To obtain the feeding-in time, however, it is necessary after obtaining the reading, to divide the result by 10. To obtain the total time required to cut the gear, add T_1 and T_2. This scale also contains a pointer for the diameter constant, which is used to obtain the pitch diameter, as will be explained in the following.

Examples Illustrating the Use of the Fellows Slide-rule

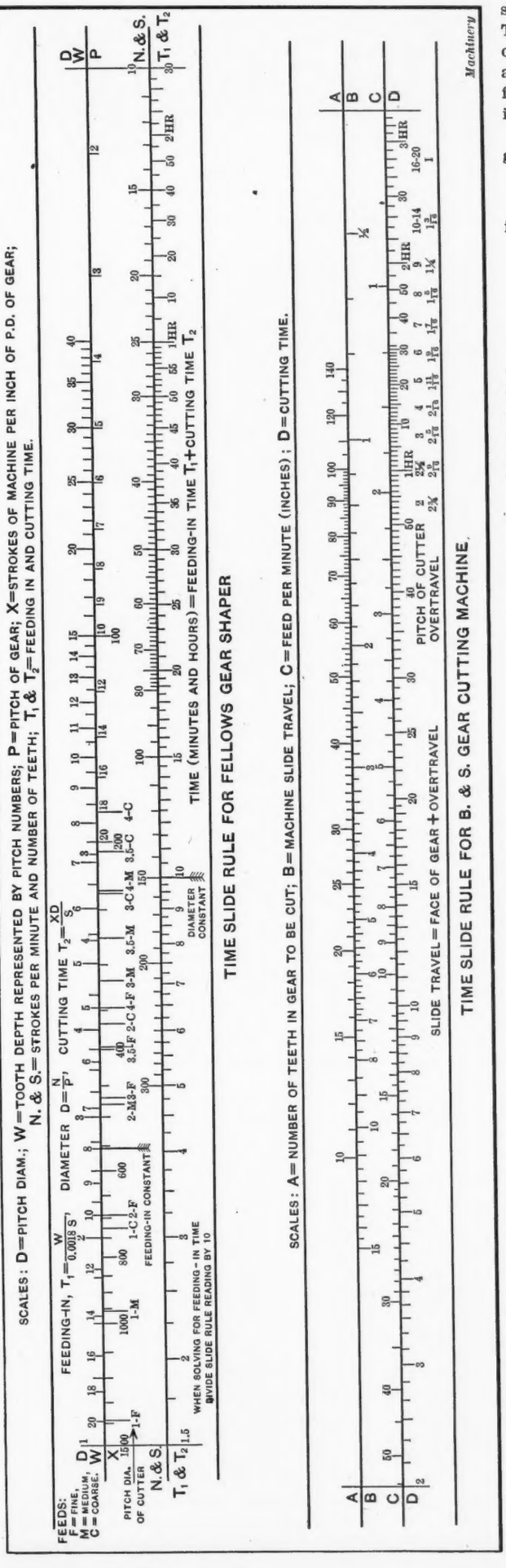
To obtain the pitch diameter of a gear of 150 teeth and 5 pitch (Formula 2), set 150 on the N & S scale of the slide opposite the pointer "diameter constant" and read, opposite graduation 5 on scale P, the pitch diameter on scale D, which in this case is 30 inches.

To obtain the feeding-in time on an 8-pitch gear with 300 strokes per minute of the machine (Formula 1), proceed as follows: It should be observed that, although the full depth of an 8-pitch tooth is 0.2696 inch, this value is not used because the scale is laid out according to the corresponding pitches. Therefore, set the pointer marked "feeding-in constant" on the slide, opposite graduation 8 on scale W, and read the value on scale T_1 and T_2 opposite 300 on the scale N & S, in this case 4.99, or approximately 5 minutes. Dividing this reading by 10 in accordance with the instructions given above, the result is 0.499, or approximately 0.5 minute for the feeding-in time.

To obtain the cutting time on an 8-pitch gear blank of 8⅜ inches pitch diameter when using a 4-inch diameter cutter with a coarse feed, the machine operating at 150 strokes per minute, first set graduation 4-C on the scale "Pitch Diameter of Cutter," opposite 8⅜ on scale D, and then read opposite 150 on the scale N & S, 10 minutes on scale T_1 and T_2. This is the cutting time. It will be noticed that graduations 4-C and 180 coincide, indicating that a cutter of 4 inches pitch diameter, with coarse feed, would make 180 strokes for every inch of pitch diameter. Thus, $\frac{4 \times 180}{150} = 4.8$ minutes for each revolution of the cutter, and since the cutter makes $\frac{8.375}{4}$, or 2.094 revolutions while the gear is being cut, 2.094×4.8 minutes, or 10 minutes, equals the cutting time. The feeding-in time will be found to be approximately one minute which, if added to the cutting time, will give the total time consumed in cutting the gear, or $10 + 1 = 11$ minutes.

Slide-rule for B. & S. Gear-cutting Machine

Referring to the illustration of the slide-rule used in connection with B. & S. gear-cutting machines it will be noted that in order to use the machine-slide travel factor, it was found necessary to embody the separate conversion table,


SCALES: D=PITCH DIAM.; W=TOOTH DEPTH REPRESENTED BY PITCH NUMBERS; P=PITCH OF GEAR; X=STROKES OF MACHINE PER INCH OF P.D. OF GEAR;
N. & S.= STROKES PER MINUTE AND NUMBER OF TEETH; T1 & T2= FEEDING IN AND CUTTING TIME.
FEEDS: F=FINE, M=MEDIUM, C=COARSE.
FEEDING-IN, T1 = W / 0.0018 S
DIAMETER D = N/P
CUTTING TIME T2 = XD/S
PITCH DIA. OF CUTTER
FEEDING-IN CONSTANT
WHEN SOLVING FOR FEEDING-IN TIME DIVIDE SLIDE RULE READING BY 10
DIAMETER CONSTANT
TIME (MINUTES AND HOURS)=FEEDING-IN TIME T1+CUTTING TIME T2
TIME SLIDE RULE FOR FELLOWS GEAR SHAPER
SCALES: A= NUMBER OF TEETH IN GEAR TO BE CUT; B= MACHINE SLIDE TRAVEL; C=FEED PER MINUTE (INCHES); D=CUTTING TIME.
PITCH OF CUTTER
OVERTRAVEL
SLIDE TRAVEL=FACE OF GEAR+OVERTRAVEL
TIME SLIDE RULE FOR B. & S. GEAR CUTTING MACHINE.
Machinery

shown in the lower right-hand corner of the illustration. To obtain the proper slide travel, add the width of the face of the gear to be cut and the over-travel of the cutter. The amount of over-travel depends upon the pitch of the cutter; for instance, the over-travel for a 2-pitch cutter is 2¾ inches.

The formula used to obtain the cutting time on B. & S. gear-cutting machines is as follows:

$$D = \frac{AB}{C}$$

in which

D = time in minutes for the gear blank to make one complete revolution;
A = number of teeth to be cut in the gear;
B = total length of the slide travel in inches;
C = feed of cutter in inches per minute.

This formula is embodied in the slide-rule, which contains four scales. The top part of the rule contains scale A, which represents the number of teeth to be cut in the gear. The slide contains two scales, B and C. Scale B represents the slide travel in inches, and scale C the feed in inches per minute. The bottom part of the rule contains scale D which represents the time required to cut a gear.

Example Illustrating the Use of the B. & S. Slide-rule

To find the cutting time of a 3-pitch, 25-tooth gear having a face width of 2⅛ inches, feeding at the rate of 6 inches per minute and cutting one gear at a time, proceed as follows: First find the value of B as used in the above formula:

B = over-travel + width of face = 2 5/16 + 2 1/8 = 4 7/16 inches.

Then substituting in the above formula the values given,

$$D = \frac{25 \times 4\ 7/16}{6} = 18\ 1/2 \text{ minutes}$$

In order to solve the problem by the use of the slide-rule, proceed as follows: Opposite graduation 25 on scale A, set 4 7/16 on scale B, and read, opposite graduation 6 on scale C, the cutting time on scale D, or 18 1/2 minutes. If it is desired to cut two or more gears at one time, the length of the slide travel will, of course, be equal to the sum of the faces of the gears to be cut and the over-travel for one gear; also, if more than one revolution of the gear is required to cut the gear, the time obtained on the slide-rule is multiplied by that number of revolutions.

Theoretically, the time consumed by the return travel of the slide should be included in these calculations, but as this is usually negligible it has been omitted. On most B. & S. machines, the return travel requires from one to three seconds. So, if in the above example the return travel consumed two seconds, the amount to be added to the calculated cutting time would be $\frac{25 \times 2}{60} = 5/6$ minutes, or 18.5 + 0.83 = 19.33 minutes = the actual cutting time.

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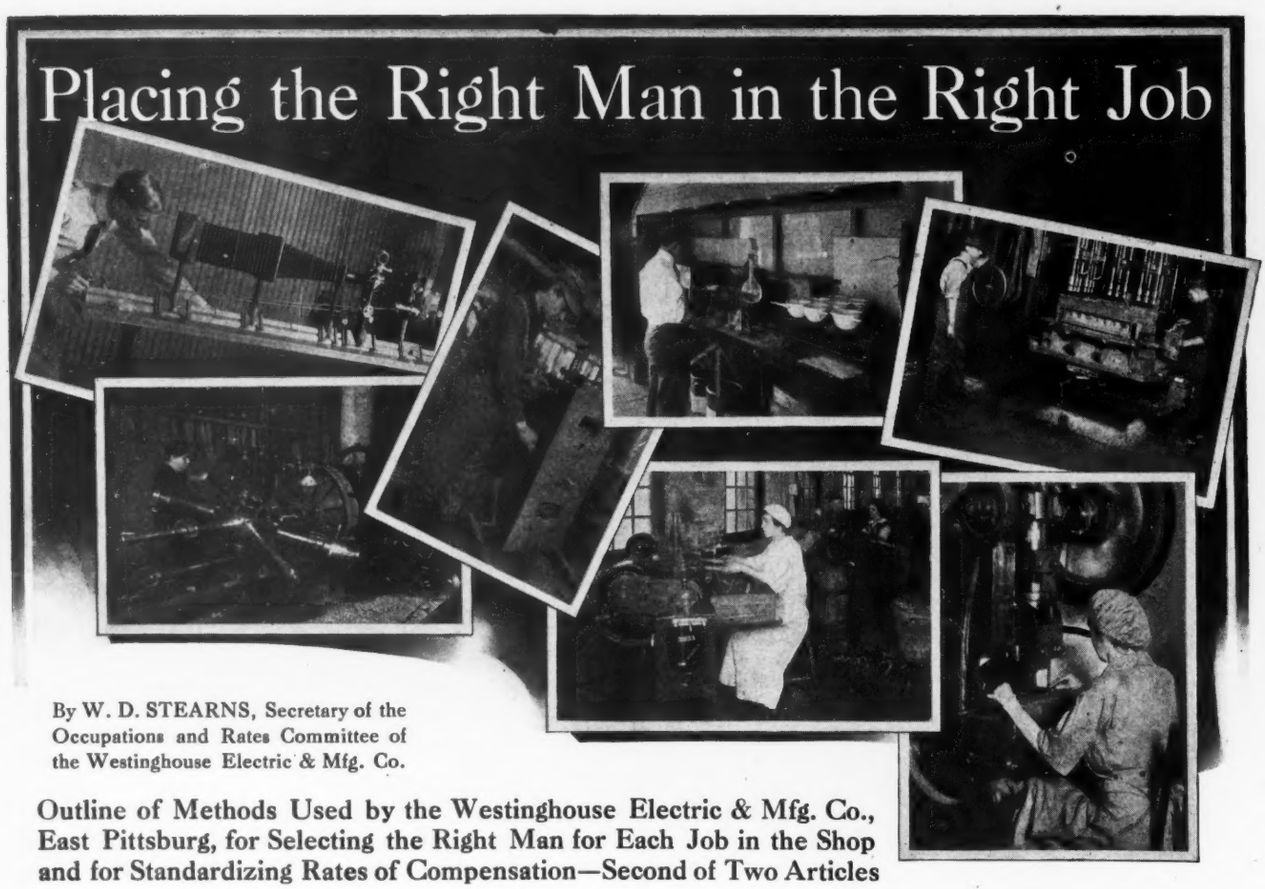
FLEXIBLE METAL TUBING

The lack of any standard method of measuring tubing with respect to its being twisted tightly or loosely, and in specifying whether or not the inside or outside diameter should be the nominal diameter has caused much confusion. Flexible metal tubing is generally supplied to the trade in diameters varying by 1/32 inch and even closer in some cases, for sizes ranging from 3/4 inch to 4 inches in diameter. The tubing thicknesses also vary and the tubing is made either with or without packing. On account of these unstandardized conditions, the tubing manufacturers have taken this matter up with the Society of Automotive Engineers, and its Miscellaneous Division, after careful consideration, has made the following recommendations: For tubing from 3/4 inch to and including 1 1/2 inches, outside diameter, sizes vary by sixteenths; from 1 5/8 to 2 1/2 inches inclusive, sizes vary by eighths; from 2 3/4 to 4 inches inclusive, sizes vary by quarters of an inch.

Placing the Right Man in the Right Job



By W. D. STEARNS, Secretary of the Occupations and Rates Committee of the Westinghouse Electric & Mfg. Co.

Outline of Methods Used by the Westinghouse Electric & Mfg. Co., East Pittsburg, for Selecting the Right Man for Each Job in the Shop and for Standardizing Rates of Compensation—Second of Two Articles

IN the first installment of this article, the standardization of occupations was dealt with, and standard descriptions of typical occupations were given. In the present installment the actual job analyses will be dealt with, and it will be shown in detail how the work of analyzing the various jobs in a large shop is carried through.

Job Analysis

When the superintendent or foreman requires supplies or materials, he writes out an order specifying what he wants in minute detail. In the same way, the job analysis card as used by the Westinghouse Electric & Mfg. Co., enables the foreman to specify exactly what he wants when he needs a man for a certain job. Figs. 1 and 2 show the two sides of the job analysis card that is used. This card is needed in addition to the occupational dictionary, because the latter is merely a foundation which provides a common language in matters relating to the occupations in the shop, while the job analysis card may be said to be the foreman's specification of the kind of man he needs. The card also gives, on the reverse side, such a description of the work as should be given to the applicant, so that he will know, before taking the job, exactly what kind of work he is agreeing to do.

All the information given on the job analysis card need not be checked ordinarily. It is necessary to check only those conditions that are unusual in some respects. Spaces need not be provided for such words as "clean," "normal temperature," etc. If the word "dirty" is not checked, it may be assumed that the job is relatively clean, and when the words "hot" or "cold" are not checked, it may be assumed that the temperature is normal. In the same way, characteristics that are desirable in all employes are omitted, unless they are of particular importance on account of the nature of the work.

The job analysis card is made in the standard 4- by 6-inch size, which is large enough, if both sides are used. As far as possible, records of this kind should be arranged so that they can be filled in by check marks rather than by writing in blank spaces, as shown by Figs. 1 and 2; and if any writing is required, it ought to be only "yes" or "no." When a space is not checked, it is assumed that this particular item is of no importance for the job specified.

There are two specific reasons for a careful job analysis. It is an aid in selecting the right man for a job, and an assistance in finding the proper kind of job for a man. When there is a scarcity of help, it is a case of selecting from the available men those that are best fitted for the jobs.

How the Job Analysis Card was Developed

In deciding upon a form for the job analysis card, it was so designed as to cover all classes of labor—skilled, semi-skilled, and unskilled, for both men and women. Each card has an individual identification number, beginning with 1 for each department. Cards which analyze jobs intended specifically for women should be marked "W," to separate them from the cards for men's jobs. Before the cards for a department are numbered, they are arranged in alphabetical order, and then numbered consecutively. The space provided for classification indicates the rate of pay, as will be explained later. It is better to have only a class indication of the rate of pay than to put down the actual rate in cents, because the rates for various jobs may change from time to time, according to labor conditions. There should also be a range of rates for every job, to take care of increased efficiency and length of service. In the line "Type of Machine Tool" will be given the maker's name, the type, and the size of the machine as it is generally known in the trade. As regards the check marks to be filled in on the card, the following remarks may prove of value:

"Colored" is checked only when there is a specific preference for colored help. "Tall," and "medium" are checked only when it is required that the man should meet one or the other of these requirements; otherwise, both are left blank. If the man must be of at least medium height, then only "medium" is checked; and if he must be tall, then only "tall" is checked. If a man must be heavy, the minimum weight is given in pounds. If age is of importance, minimum and maximum ages are stated. Under "experience" is given the required experience in months or years, or, in general, the time that it would take a man to obtain average

efficiency in the work. "To learn" is checked when the applicant is expected to learn the work in the shop, and "how taught" indicates whether the employe is taught by an instructor in the department, by personal experience, or in a special training department. If the operator should own any tools, these are specified.

A study of the reverse side of the card will show that this gives a brief description of the work. Most of the items here given are self-explanatory. If "repetition" is checked, it indicates that the work is a repetitive job, and hence of a monotonous nature. The number of men and women engaged on the same work is given, because sometimes this may affect the type of employe that would be selected for a special job.

In preparing the job analysis card, the cooperation of the foreman is necessary. The best way is to go over each job analysis with the foreman, the men having the job analysis in charge doing the checking. If time is limited, the cards may be distributed to each foreman, and he may fill them out himself for every job in his department. The details, of course, should be thoroughly explained to him before he is asked to check the cards. A more uniform result will be obtained if the man who has charge of the job analysis cards goes over each job, item by item, with the foreman. As it is necessary that all the cards be placed on a standard basis, as nearly as possible, the latter plan should be used. When all the cards have been filled out, they are classified according to occupation, and then those covering the same class of work in each occupation are made to harmonize with each other, so that, in every case where it is intended to express the same idea, the wording on the cards also conforms.

THE WORK:—

☒Heavy	☒Standing	☐Hot	☐Fumes	☒Day Work
☒Light	☐Sitting	☐Cold	☐Oils	☒Premium
☒Close	☐Stooping	☐Wet	☐Acids	☐Piece Work
☐Rough	☐Reaching	☐Dirty	☐Hard for Hands	☐Standard Time
☒Hand Lift	☐Repetition	☐Dusty	☐Eye Strain	☐Group
☒Crane Lift	☐	☐	☐	☐Task

Approximate number engaged in this work: Men 2 Women

Type of machine tool 24" x 60" Pittsburg Engine Lathe

Materials used Copper, brass, steel and cast iron.

Description of work Turn steel fields, commutators, collectors, couplings, etc.

Westinghouse Electric & Mfg. Co.

Fig. 2. Back of Job Analysis Card shown in Fig. 1

Proper Use of Job Analysis Cards

It would be possible to have each requisition for help in the form of a job analysis which would be filled out each time the foreman needed a new man. If this plan were used, the record would always be up to date, but it has several serious disadvantages. The foreman's time would be taken to make out a complete job analysis card whenever he should need a new man. The information on the card would not be uniform and would often be hurriedly indicated; hence requisitions made from time to time by the same foreman would not be consistent with each other, and the requisitions from different departments would vary widely. The correct way to use job analysis cards, therefore, is to have a complete set of cards filed in the employment department, the foreman having a duplicate set in his department. The foreman then merely gives the number of the card to the employment department, and by referring to that card information is obtained as to what kind of man to select. The cards, of course, must be kept up to date, because there are constant changes taking place. Some jobs are cancelled, and sometimes the equipment in the shop may call for new requirements in the employe.

Classification of Jobs with a View to Obtaining Standard Wage Rates

When the occupations have been standardized and the job analysis cards made, the jobs may be classified with a view to obtaining a standard for the payment of a fair wage. This can be done more easily after the work already outlined has been completed, so that all the requirements are known and the relative values of the various jobs are understood. The classification of the jobs with a view to obtaining fair wage payments is, in fact, the most important part of the whole work, and the preceding steps have merely been taken to lead up to this point.

The jobs, and not the employes, should be classified. The employe's value to the company is not based upon what he may be capable of doing, but upon what he is actually doing on the job that he holds; hence, the classification relates to the job and not to the man. By having a classification of the relative values of the jobs, however, there is a chance not only to compensate the men properly for the work they do, but also to promote them to jobs that pay better, when they prove capable of doing higher grade work.

Form 5779-D

JOB SPECIFICATION FOR SHOP EMPLOYEES

Job No. 5

Dept. Power Div. Winding Sec. C-3

Occupation Lathe, Engine No. 68 Class B

THE WORKER:—

Age Limits 25-40 Minimum Weight 150

☒Man	☒Speak English	☐Strong	☒Accurate	☐Use Jigs
☐Woman	☒Read English	☐Quick	☐Thorough	☒Gauges
☐Tall	☐Write English	☒Deliberate	☐Good Memory	☐Templates
☒Medium	☐6th Grade	☐Patient	☒Read Scale	☒Micrometer
☐Colored	☒8th Grade	☐Observant	☒Set Up Work	☒Prints

Tools Operative Should Own Calipers, dividers, scale and feelers.

Experience (Time) Previous 1-2 yrs. To Learn How Taught experience

Promote From Lower grade lathe To higher grade lathe

Remarks:

Fig. 1. Job Analysis Card for Shop Employes

Determining the Relative Values of the Jobs in the Shop

There are five important reasons why one job is of a higher relative value than another: (1) The work may require knowledge obtained only by long experience. (2) It may require manual skill which can be obtained only by long practice. (3) It may require physical strength. (4) It may require executive ability. (5) The working conditions may make the job undesirable, because the hours are long, because of night work, or because the work is dirty, hot, cold, unhealthful, or dangerous.

In addition, there are a number of other factors which must be taken into consideration. For example, two jobs may require a similar operation, but in one case, the operation may be performed on a simple part, and if spoiled, the loss in material or labor would be small. In the other case, the same

JOB SPECIFICATION FOR OFFICE EMPLOYEES — Form No. 7542

Job No. 27

Dept. Sales Division Clerical Section 2

Occupation Stenographer No. 515 Class B

The Worker:— Age Limits

☐ Man	☐ Grade	☒ English	☒ Accuracy	☐ Memory
☒ Woman	☒ High School	☐ Mathematics	☐ Alertness	☒ Initiative
☐ Tall	☒ Commercial	☒ Stenography	☐ Analytical	☐ Observation
☐ Medium	☐ Technical	☒ Typing	☐ Concentration	☒ Speed
☐ Short	☐	☐ Writing	☐ Deliberate	☒ Systematic
☐	☐	☐	☐ Executive	☐ Tact

Experience (time) Previous 2 years To Learn How Taught Experience.

Remarks— Should avoid extremes in appearance and have poise.

Fig. 3. Job Specifications for Office Employes

operation may be performed on a part on which much labor has already been spent, so that if the work is spoiled, the loss involved may be great. It is evident that the job in the second case requires a careful and dependable man, and hence, the value of the job is relatively higher.

Division of Classification

At the Westinghouse plant, jobs have been divided into five main classes as follows:

Class A—This class covers jobs requiring only those "masters of their trade," who thoroughly understand their work in a broad way, and who are competent to work without immediate supervision; jobs requiring leaders in charge of groups, experimental workers, and those on the highest grade production or tool work. General knowledge of machine tools, speeds, materials, etc., judgment, accuracy without the use of jigs, and a high degree of skill and dependability are required. *Examples*—Engine lathe, planer, and boring mill operators on very large work where great loss is incurred if mistakes are made; engine lathe operators on smaller accurate work not depending on grinding for final finish; tool work, such as thread gages; machine tool repair work; winders on turbo and large generator work; and experimental work.

Class B—This class may require as good a worker on certain specific operations as does the Class A job, but his experience does not need to cover as broad a field and he requires some supervision; accurate, dependable workers with considerable ability and experience, but who do not have the thorough knowledge or experience required of those in Class A; operators on accurate or heavy work which is usually repeated. Accuracy, knowledge of speeds and materials, reading of blueprints and use of gages are required. *Examples*—Engine lathe operators, work not especially accurate, but laborious; work on smaller lathes where there is great responsibility, as on commutators and collectors after they have been assembled on shafts. Planer operators on medium sized repetitive work. Vertical boring mill operators on large work or on accurate, difficult work on smaller mills.

Class C—This class is intended to cover specialists, or "machine operators," rather than mechanics. It is intended to include workmen who have become proficient on specific operations. *Examples*—Engine lathe operators on repetition work and roughing shafts. Planer operators on rough work, such as roughing stock for poles. Boring mill operators on small repetition work.

Class D—This includes jobs requiring the type of man who is somewhat above the laboring class and who shows a reasonable degree of intelligence and interest in his work, with a desire to learn. On these jobs, in general, the workman is trained for a Class C job. It also covers jobs so simple, and which take so short a time for training, that they are not included in Class C. *Examples*—Employes learning to operate engine lathes, planers, and boring mills, and learning to wind. Stockmen, filers, chippers, machine helpers, and punch press operators.

Class E—This class covers what are usually called laborers. These are unskilled workmen with practically no previous training; men on work where only a small degree of skill, accuracy, or knowledge is needed. The jobs are rough, and the operations are repeated and are extremely simple, requiring a minimum of time to learn. *Examples*—Truckers, material handlers, sweepers, machine helpers, janitors, and ashmen.

Table 1 in the article in the September number, giving the occupations in the plant of the Westinghouse Electric & Mfg. Co., also gives the classification that is used for the different occupations. It is evident that each occupation may embrace several classifications. For example, by referring to the table, it will be found that milling machine operators are in either Classes A, B, C, or D. This depends entirely upon the nature of the work performed on the machine—whether it is rough plain milling or a high-class special milling job, such as spiral gear cutting or similar work.

In classifying the jobs, five drawers were used, and the cards were sorted by putting those for each class in one drawer. In doing the work, it was found that some jobs were sorted with little or no difficulty, those that were most easily sorted being Class A and Class E. When there was doubt about the proper classification, the card was set aside for further consideration, and after the sorting was completed, the cards in the different classes were compared to see that they were properly classified. In doubtful cases, an investigation was made, and the foremen in the different departments were asked to cooperate in determining the class in which the job should be put.

Use of Classification of Jobs

As soon as the jobs in the shop had been classified, the Committee on Occupations and Rates, which represents the management and the employment, the time-study and the

The Work:—

Hours 8:30 to 5:00 Sat 8:30 to 12:15 ☐ Regular Overtime

Promote From Lower grade stenographer to Secretarial work.

Approximate Number on This Work—Men Women 4

Objectionable Features Machine Royal typewriter.

☐ Adding Machine	☐ Blue Prints	☒ Sitting	☐ Check
☐ Comptometer	☐ Routine	☐ Standing	☐ Hourly
☒ Dictaphone	☐ Supervised	☐ Reaching	☒ Salary
☐ Slide Rule	☐	☐ Walking	☐

Description of Work:— General stenographic work, taking dictation from four or five men, small amount of dictaphone and copy work. Outside correspondence.

Westinghouse Electric & Mfg. Co.

Fig. 4. Back of Card shown in Fig. 3

manufacturing departments, went over the classification and set the rates to be paid for each class. This committee is a permanent one, and approves changes in the rates and also the addition of new occupations and classifications. The committee also investigates all conditions that arise in connection with the rates of pay in force at the factory. It is understood that the classification should not be altered unless the nature of the work or operation is changed, because changes in classification mean changes in wage rates.

If it should be found, however, that the rate specified for a job is insufficient for a certain employe, and if it is believed that he is fitted for work in a higher classification, then he should be promoted to a job requiring greater skill. If at any time the requests for increases in pay on a large number of jobs are numerous, it is an indication that there should be a flat increase in the wage rate. In that case, the committee passes upon the rate and recommends a higher rate, if it deems this advisable.

Method of Determining Rates for the Various Classes of Jobs

When a classification is completed, the actual wage rates in cents are set for each class. First the rates which are paid for Classes A and E are determined by making a study of the prevailing wages in the locality for these classes of labor. Having set a rate for these two classes, the rates for the intermediate classes are interpolated between them. A so-called "key sheet" is provided which gives the rates for each class. The rates might be somewhat as follows:

Class	Day-work Rate
A	71-80
B	61-70
C	51-60
D	41-50
E	30-40

Piece-work rates and premium rates are graded according to the day-work rate. The key sheet should also give these rates. When, for example, a system is used by which an employe is paid a higher rate for work that is performed in a given time, this standard time rate is a certain percentage greater than the day-work rate—perhaps 10 per cent. The key sheet for Class A, in that case, might be as follows:

Class	Day-work Rate	Standard Time Rate
A	80	88
A	79	87
A	78	86
A	77	85
A	76	84
A	75	82
A	74	81
A	73	80
A	72	79
A	71	78

If, for example, six hours' time is allowed for a given job and the day-work rate is 88 cents per hour, then an employe performing this work in six hours or less will receive $6 \times 0.88 = \$5.28$ for the work. The standard time rate arranged on this basis makes it possible to pay proportionately higher standard time rates to men whose regular day rate is high. The Westinghouse company makes it a rule to hire men at the minimum rate in each class, and the higher rates are used only for the most skilled in that class. Furthermore, the higher class occupations requiring skill, experience, or special ability are filled whenever possible by promotions or transfers within the organization.

Conclusion

These systems, much as outlined above, have been in use at the Westinghouse plant for several years, and have proved entirely satisfactory. They aid in the intelligent hiring of men for the jobs for which they are intended, make it possible to give the men an idea about the work they are expected to do, and make it possible to pay the employe a fair and equitable compensation based upon the work that he is doing. The savings that have been accomplished through these systems cannot be definitely estimated in dollars and cents, but the benefits have been so great that the general methods are being constantly perfected and extended. Recently, the system has been applied to office employes as well, the job analysis card for these employes being shown in Figs. 3 and 4.

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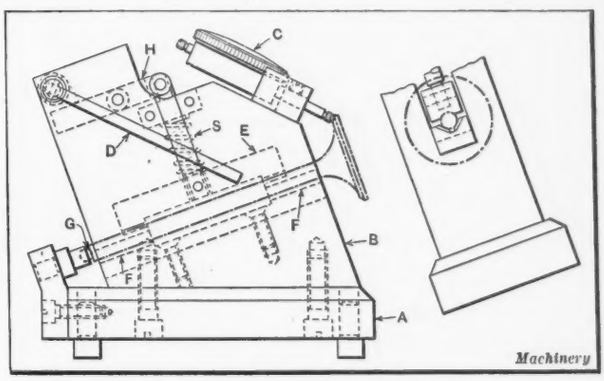
CONCENTRICITY GAGE FOR POPPET VALVES

By J. L. HAYES

A gage for testing the concentricity of the face or seat of a poppet valve in relation to its stem should be designed so as to be easily operated and yet function accurately. Such a gage is shown in the accompanying illustration, consisting of three principal parts, the base *A*, body *B*, and the dial indicator *C*. All the smaller parts are mounted in the body except the stop, which is attached to the base. The dial indicator is mounted on the body at an angle of 45 degrees to the center line of the valve, when it is located in the gage. This angular position brings the point of the indicator perpendicular to the face of the valve. The position of the indicator may be slightly adjusted to overcome wear on its point.

In using the gage to inspect valves, the cam-lever *D* is first pressed downward slightly, which raises the jaw *E* by means of the fulcrum lever *H* and its connection to the jaw. The jaw is grooved to fit the valve stem, and after the piece has been placed in the V-blocks *F*, the lever *D* is released



Indicator Gage for inspecting the Concentricity of Poppet Valve Seats

and the action of the spring *S* seats the valve stem and holds it lightly, the end resting against the hardened steel ball *G*. This ball is free to revolve, and furnishes a single-point stop for the stem—an arrangement which allows the valve to be revolved when inspecting the concentricity of its face, without disturbing its lateral position. It can readily be seen that by turning the valve and observing the deflection on the indicator hand, an accurate inspection of the concentricity of the face can be made. The position of the valve, which is inclined at an angle of 20 degrees makes it convenient for the operator to inspect it.

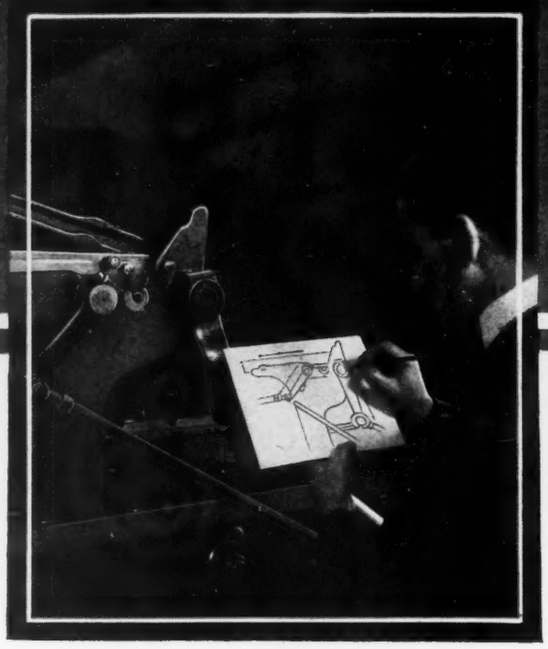
* * *

MACHINE TOOLS IN LATIN-AMERICAN SHOPS

In an address made at the Second Pan-American Commercial Conference held at Washington, D. C., June 2 to 6 inclusive, Commissioner Frederick A. Halsey, American Institute of Weights and Measures, stated that an accurate census of the machine tools in Latin-American shops and factories under pre-war conditions shows that 39.3 per cent of the tools were made in the United States and 43.2 per cent in Great Britain, a total of 82.5 per cent being therefore made to the English system, while the remaining 17.5 per cent were made in France, Belgium, and Germany and to the metric system. Mr. Halsey does not think that our manufacturers of machinery will follow the advice of the well-meaning gentlemen who have no knowledge of the industry, but who state that Latin-America will not buy machinery manufactured in the United States unless made to the metric system.

Mechanical Sketching

By F. D. Jones



The Value of Sketches in Mechanical Work, and a Simple but Rapid Method of Making Neat, Well-proportioned Sketches of Tools and Machine Details without the Use of Drawing Instruments

PENCIL sketches are commonly used by almost everyone engaged in mechanical work. The inventor and designer frequently uses rough sketches in developing new appliances, the mental picture being transferred to paper so that it becomes clearer. Sketches assist in developing an idea, and they often reveal faults, or show that the idea is entirely impracticable. A number of sketches are often made to illustrate different solutions of the same problem. During the preliminary steps in the development of a design, free-hand sketches may serve the purpose about as well as accurate drawings, and the former are preferable since they can be made quite rapidly.

Another important use of sketches in mechanical work is for showing the form and arrangement of existing devices, such as tools, machine details, or a complete mechanism. The original drawings of a machine may have been destroyed by fire or lost; and if new ones are needed, rough free-hand sketches are frequently made first, because it is not convenient for the draftsman to make the scale drawings directly from the machine. After one or more sketches have been made, all important parts of the machine are measured, and these measurements are marked on the sketches, which are then used by the draftsman as a guide for making a more complete and accurate drawing.

Sketches are used universally to illustrate ideas of a mechanical nature. For instance, whenever there are discussions on mechanical subjects, a pencil and paper are generally required to show by a drawing or sketch what cannot be explained clearly by words alone. While the ability to sketch is essential to the draftsman or designer, at least some skill in sketching is also useful to the man in the shop. The machinist or toolmaker often relies upon a sketch to illustrate some existing tool or mechanism, or as the means of representing what is considered, at least, to be a new or improved device or method. Drawing has sometimes been referred to as the "language of the shop," and inability to draw or sketch is often a great handicap to the shop man.

Experienced machinists and toolmakers usually know more or less about mechanical drawing methods owing to the continual use of blueprints in the shop. They understand what the different views represent, or are able to "read a drawing." Practice in the reading of various kinds of drawings tends to teach the methods of making mechanical drawings, so far as the number of views required and their arrangement are concerned; but the actual making of a neat drawing or sketch especially without the use of instruments, requires practice and the understanding of a few simple principles. It is the purpose of this article to give a few hints on sketching to shop men who are already familiar with the projection method of drawing, and also to draftsmen who find it difficult to make satisfactory sketches. It is a mistake to suppose that neat sketches can only be made by those having a special talent in that direction. Most machinists and toolmakers can become fairly proficient in sketching if they are willing to practice, and it is important to remember that the amount of practice necessary can be reduced greatly if the proper methods are followed.

An Important Principle in Sketching

The real difference between a poor sketch and one that is neatly executed is that a poor sketch is composed of crooked lines which are not of the right length or do not bear the proper relation to one another, while in a good sketch the reverse condition obtains. Now, most mechanical drawings, whether they represent a complicated mechanism or some simple part, consist largely of straight horizontal and vertical lines, which vary as to length and as to their location relative to one another. The first step, then, in acquiring skill in sketching without the aid of instruments, is to learn how to draw fairly straight lines, and the next step is to make lines of the right length and place them where they belong. That sounds easy and it is not as difficult as many imagine.

A finished sketch may appear complex and difficult just because it is composed of many different lines. The drawing of a few lines would not seem difficult, but when a lot of lines are combined to form a complete drawing, the making of such a sketch is considered almost impossible by many mechanics who have never considered themselves handy with a pencil. Now the fact is that a sketch which is formed of a mass of lines may be drawn almost as easily as a much simpler one, except that more time is required. If two straight lines can be drawn on a sketching pad, there should be no difficulty in drawing four, eight, or any required number of lines; and that is an important point to bear in mind. It is, in fact, a principle which applies not only to drawing but to the building of machinery and to a thousand and one other activities. If each detail of the work is carried on correctly, the completed job, whether it be a sketch or a complex machine, will finally be the result. The appearance of the completed work may prove rather deceptive. It may seem to the inexperienced as hopelessly difficult, when it is merely a lot of simple details put together in the right way.

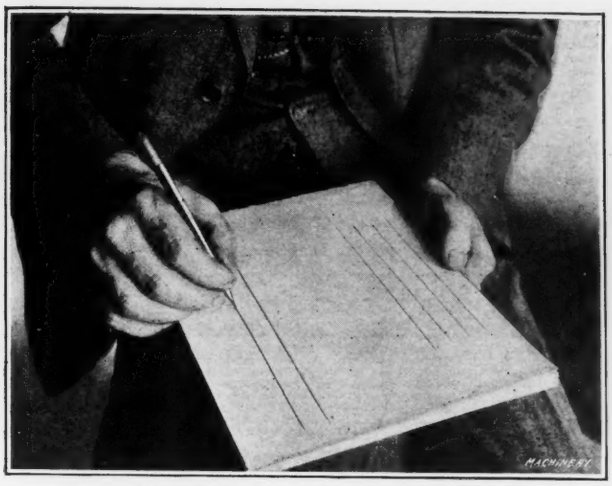


Fig. 1. Drawing Straight Parallel Lines by guiding the Pencil from the Edges of Sketching Pad

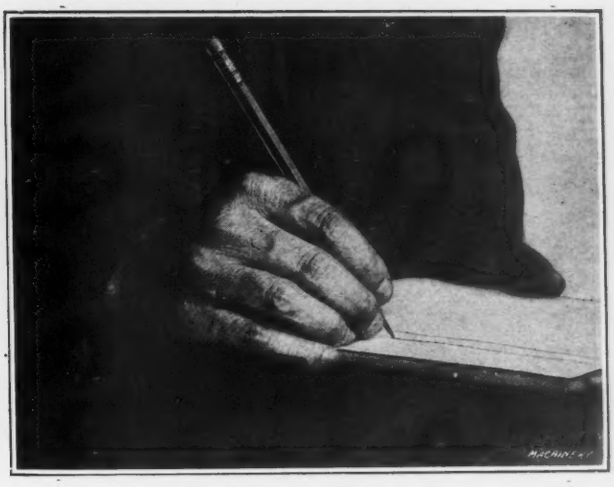


Fig. 2. End of Little Finger is held against Edge of Pad so that Pencil will follow a Straight Line

Most drawings, as was said before, are formed largely of straight lines that are perpendicular to one another. Some drawings also have quite a number of circles or arcs of circles, and there may be, in addition, lines at various angles to each other, and irregular curves. It is evident that one who can draw these lines, and especially the straight ones, with fair accuracy, without using mechanical drawing instruments, has at least a good chance of becoming reasonably proficient in the art of sketching. Locating and proportioning the lines is another essential requirement. These two general features of sketching will be dealt with.

Drawing Straight Parallel Lines

It is preferable when sketching by the method to be explained to use a pad having a cardboard back to make it rigid. The size of the pad is not very important, although an 8- by 10-inch size will be found convenient for most sketching. A good exercise to begin with is that of drawing straight parallel lines. An easy method of doing this is illustrated in Figs. 1 and 2. The pencil is guided, as it is drawn across the paper, by one finger which slides along the edge of the pad. Either the little finger or the ring finger next to it is used to guide the pencil, depending on the distance from the edge of the pad to the line to be drawn. Unless the line is quite close to the edge—say less than one inch—the little finger should be used (see Fig. 2). As the little finger follows the edge of the pad, the ring finger slides lightly over the top surface of the pad and supports the hand. By adopting this simple method, lines that are practically straight and parallel can be drawn with a little practice, and the movement of the pencil can be quite rapid without impairing the straightness of the lines; in fact, a somewhat rapid stroke is preferable. This method will be found decidedly superior to the common way of attempting to draw a straight line by a series of short successive follow-up strokes.

After it has become easy to draw straight lines near the edge of the pad, the pencil should be moved nearer the center as shown in Fig. 3. This exercise is a little more difficult because the pencil is farther from the guiding finger. The pencil is held at different distances from the edge of the pad simply by separating the guiding finger more or less from the remainder of the hand. When making a sketch, that edge of the pad nearest the line to be drawn should ordinarily be used for guiding, and in this way the entire surface can be covered, provided it is not over 8 or 10 inches wide.

The next exercise should be that of drawing lines of various lengths at right angles to one another as illustrated in Fig. 4. The pencil is guided by the little finger the same as before, and the end of the pad is used as well as the side. These exercises should be continued until the drawing of lines by this method becomes natural and easy. Simple figures, such as squares and rectangles of different sizes, should be drawn next to obtain practice in the matter of locating the lines properly and getting them somewhere near the right length. This next step is a little more difficult than the first because drawing a lot of miscellaneous lines is much easier than making a drawing of some definite object.

How to Proceed when Making a Sketch

If the shape of a casting or forging or the arrangement of some mechanism is to be shown by a sketch, the lines which

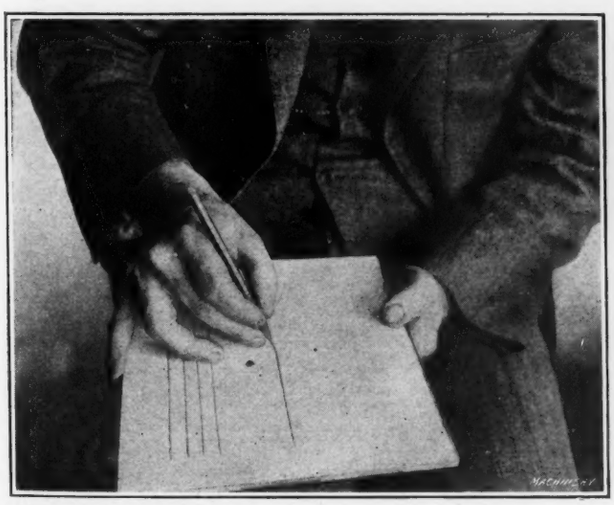


Fig. 3. Position of Hand when drawing a Straight Line which is located near the Center of the Pad

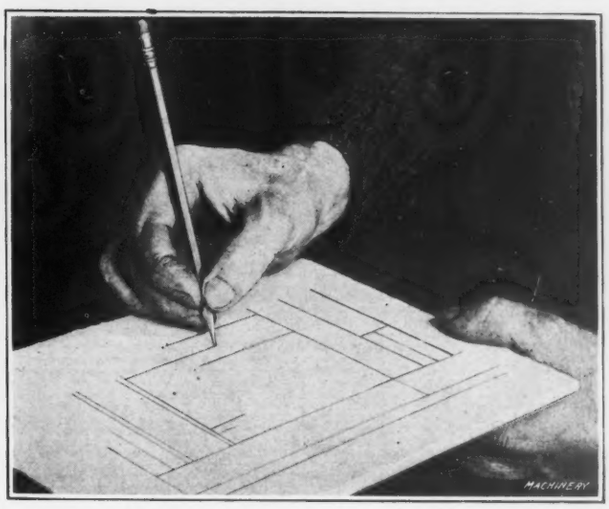


Fig. 4. Lines drawn at Right Angles and in Different Positions by guiding Pencil from Four Edges of Pad

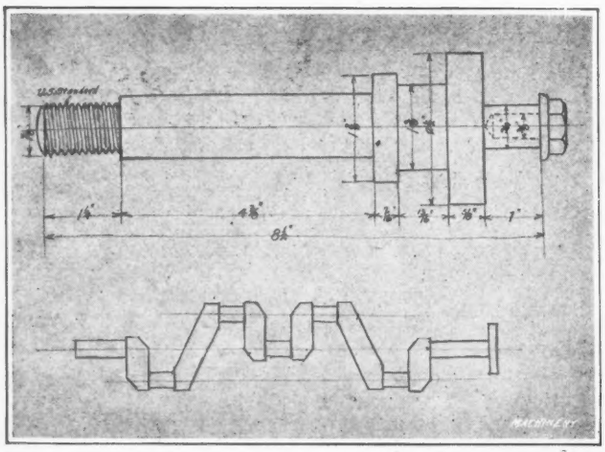


Fig. 5. Illustration showing Methods of Procedure in making Sketches

form it must be properly proportioned, their length and location agreeing approximately with the size and location of the different surfaces or parts which they represent. Success in this branch of the work is achieved partly by method and partly by practice. Some sense of proportion is also needed, but most machinists are good judges of short distances and should be able with practice to proportion a sketch accurately enough if the right method is adopted. It is important to draw the main parts first and then the details, because the proper proportions and locations are secured more easily in this way.

In order to illustrate some of the points to be observed when sketching and the general method of procedure, one or two practical examples will be given. As an illustration, suppose a sketch similar to the one shown in the upper part of Fig. 5 is to be made. The first thing to decide is how and where to begin. It would be possible to start in several different ways. For example, we could first draw the collar at the right-hand end, then the threaded end at the left, and finally connect these sections by drawing the long horizontal lines, but it is quite evident that this would not be the best way to proceed. The proper way would be to first draw a center line, then the principal lines, and finally the smaller details. Center lines are not always needed in sketching, but as a rule they enable the different parts, even of a simple sketch, to be more accurately located relative to each other. Take for example the sketch of a gas engine crankshaft shown in the lower part of Fig. 5. In this case, it is desirable to have different bearings approximately in line. To accomplish this, three parallel and equally spaced center lines extending lengthwise of the shaft should be drawn first. If these lines are drawn fairly straight and are spaced about equally, the crankshaft can be sketched around them easily. This shaft could also be sketched without center lines by first drawing lightly three sets of double parallel lines. The two lines in the center serve as a guide for aligning the shaft bearings, and the outer lines serve to locate the crankpin bearings. The shaft is then drawn in heavier lines by beginning at one end and finishing each crank successively.

It is not necessary or advisable to guide the pencil from the edge of the pad for drawing all straight lines. This would be a very awkward way to draw the numerous short connecting ends which form the smaller details on many sketches. The pencil should only be guided when drawing the longer lines which form the principal part of the sketch. For instance, when sketching the crankshaft, the pencil should be guided while drawing the center lines or the light parallel guide lines, but the cross lines are so short in this instance that they could doubtless be drawn to better advantage without attempting to steady the hand from the edge of the pad. A sketch of this kind could be made easily on cross-sectioned paper, but such paper may not always be at hand, and a plain pad is just as good for many purposes. The cross-sectioned paper with its guide lines accurately spaced is excellent when it is of especial importance to make a sketch accurate to scale.

Whenever possible, only one view is shown on a sketch, even though two views might be considered necessary on a working drawing. Many parts are understood to be round or of circular cross-section by mechanics, and an end view is not needed or, in some cases, an explanatory note may be added to the sketch to avoid an extra view. If one section of a circular piece were of special shape or had a slot cut in it, it might be advisable to make an additional view.

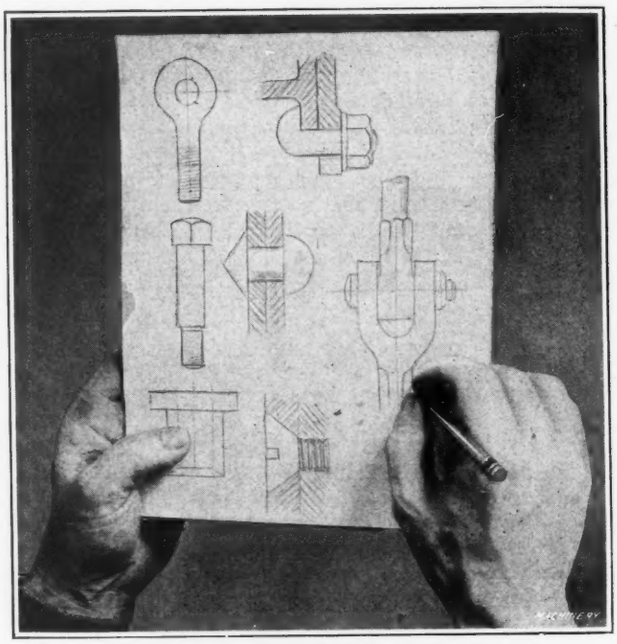


Fig. 6. Sketching Small Details—an Exercise in drawing Lines and in proportioning Parts

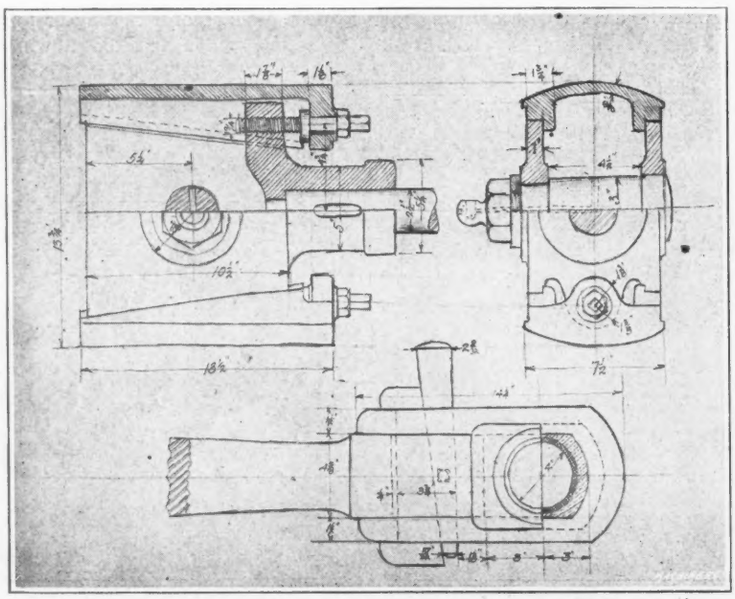


Fig. 7. Engine Details. Note how Straight Horizontal and Vertical Lines predominate in these Sketches

The sketching of small details such as are shown in Fig. 6 is good practice and should precede the making of larger sketches. When starting the sketch it is often advisable to draw very light guide lines which serve to block out the principal parts of whatever object is being drawn. Such guide lines, as a rule, will greatly assist in proportioning the sketch and make it possible to complete a sketch with

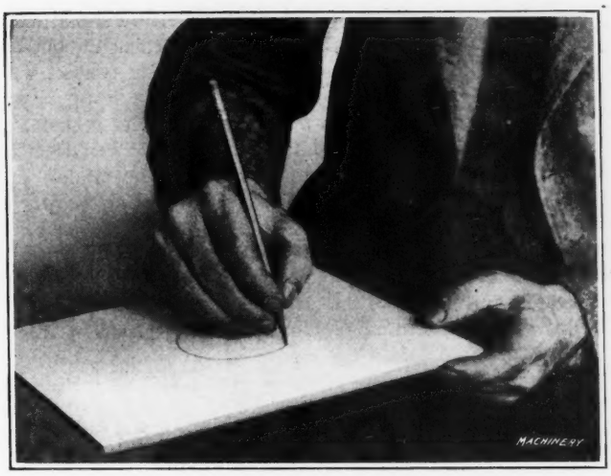


Fig. 8. Drawing a Circle by turning Pad beneath Pencil which is pivoted between Knee and Little Finger

Fig. 9. The Joint of the Little Finger may be used as a Pivot when drawing the Larger Circles

little or no erasing. When simple details can be drawn readily sketches of larger and more complicated parts should be made. The example shown in Fig. 7 represents an engine cross-head and one end of a connecting-rod. These sketches illustrate the important point that plain straight lines which are parallel and at right angles to one another form a large part of most sketches. There are doubtless many mechanics who do not believe that they could make sketches even after considerable practice, which would be as well proportioned as those shown in Fig. 7, and yet knowing how to draw straight parallel lines by guiding the pencil from each of the four edges of the pad is practically all that is necessary in making sketches of this kind, aside from the ability to judge distances between lines and their relative lengths.

When lines are at an angle with the sides of the pad and the finger cannot be used for guiding the pencil, a good way to draw such lines is to look at the point on the paper where the line is to end and then move the pencil quite rapidly toward this point. When drawing lines of this sort a bold and fairly rapid stroke is better than a slow hesitating movement. The eyes should be fixed on the place where the line is to end instead of following the pencil point. With a little practice, diagonal lines that are quite straight can be made in this way.

Proportioning the Parts of the Sketch

When a mechanical drawing is being made, the length and position of the lines depends upon measurements; but when making a sketch of some mechanical device or machine part, judgment regarding the relative sizes of the different details is needed to secure the proper proportions, although, as previously mentioned, one's judgment can be greatly aided by proceeding in the proper way. As an illustration, assume that a sketch is to be made which represents a side elevation of a planer. A good way to begin this sketch would be to first draw the long lines representing the bed, by guiding the pencil from the edge of the pad. The length of the lines would be governed entirely by the size of sketch wanted. The vertical lines which represent the front side of the housing would then be drawn to a height proportional to the length of the bed. That is, if the housing of the planer being sketched is judged by the eye to be about one-half as high as the bed is long, the height of the vertical lines should be one-half the length of the horizontal lines. Other important parts can be proportioned in the same way. After the large parts have been sketched to about the correct proportion by this comparative method, it will be found quite easy to draw the details somewhere near the right size. This idea, as applied to sketches generally, may be summarized as follows: Draw the long or "foundation" lines first and then it will be comparatively easy to sketch in the small details.

There is a decided advantage in making the principal lines fairly accurate and straight, not so much to secure neatness as accuracy of proportion. A drawing can be quite rough and "sketchy" and still be a good representation of the part drawn, provided the proportion is somewhere nearly correct.

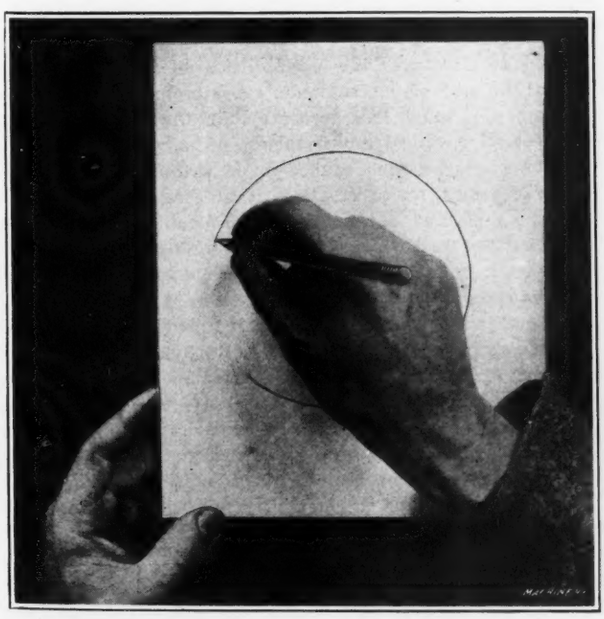


Fig. 10. View showing Accuracy of Circle which may be drawn

Fig. 11. Drawing Arc of Large Radius by using Elbow as Pivot

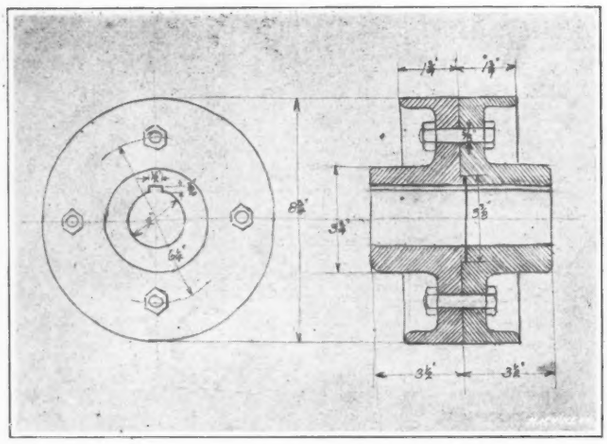


Fig. 12. Sketch of Flange Coupling

This is illustrated by the fact that when a mechanical drawing which has been made by the use of instruments is traced free-hand on transparent paper, the lines may be rough and uneven, but the drawing has a good appearance, nevertheless, because the proportions are accurate.

Free-hand sketches should not be relied upon too much, particularly when they are used in originating new forms of mechanism or designs which are rather complex.

Drawing Circles without Instruments

Thus far nothing has been said about drawing circles, and unfortunately some sketches require circular as well as straight lines. It is rather difficult to draw, free-hand, what, even in the spirit of charity, might be called a circle although circles can be drawn quite satisfactorily by the method illustrated in Figs. 8, 9, and 10. The circle is drawn by turning the pad around instead of the pencil. The pad is supported on the knee, and the little finger of the hand, holding the pencil, supports the hand, and should be directly over the knee to act as a pivot for the pad. The end of the finger may bear against the pad, as shown in Fig. 8, but, for the larger circles, some prefer to form a pivot by bending the finger so that the first joint rests upon the pad as in Fig. 9. It is necessary to apply some pressure in order to prevent the hand from shifting relative to the pad which is turned around by the other hand. Fig. 10 shows how accurately a circle may be drawn by this simple method. Circles of different diameters may be drawn by varying the distance between the pencil and the little finger. This method of drawing a circle is very convenient, although it requires some practice. Quite accurate circles may also be drawn by this method upon a single sheet of paper. The latter is placed upon a table or board and is slowly turned about the point where the little finger holds the paper in contact with the board.

When a large circle forms a prominent part of a sketch it is better to draw it first, as the other details can then be located and proportioned with reference to the circle. For example, when making a sketch of the coupling shown in Fig. 12, the circle representing the outside of the coupling should be drawn first. A center line is then drawn through the circle, and in this way the sectional view is located quite accurately in relation to the circle. If an attempt were made to draw the center line first and then the circle, it might prove difficult to locate the center of the circle exactly on the center line when the circle is drawn by the method illustrated in Figs. 8 and 9. The sketch of this coupling, as well as the other sketches shown in connection with this article, were drawn by following the methods described.

The gearing sketch shown in Fig. 13 is another example

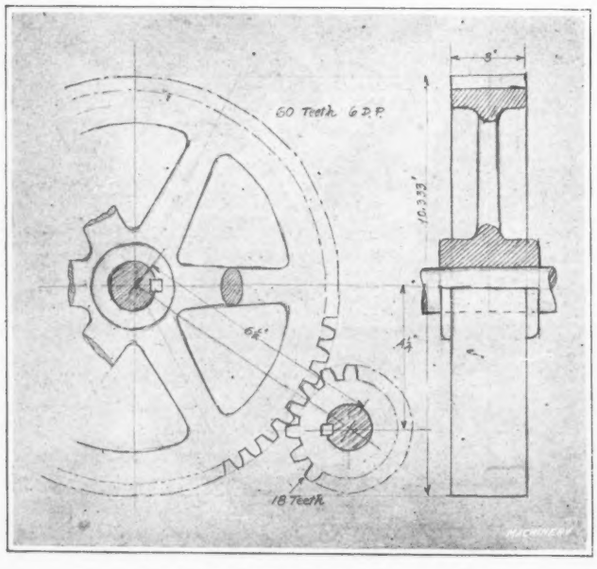


Fig. 13. Sketch of Spur Gear and Pinion

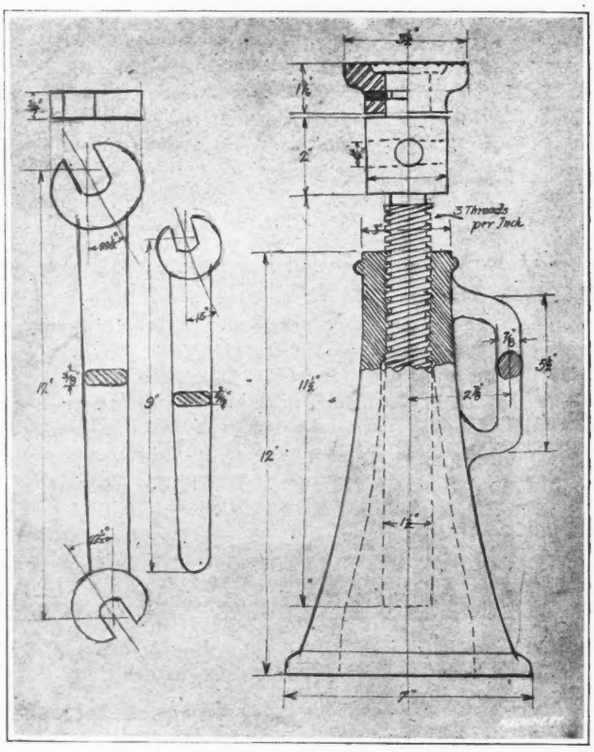


Fig. 14. Sketch of Wrenches and Screw Jack—Curved Lines of Jack Body are drawn by Method illustrated in Fig. 11

intended to illustrate the possibilities of drawing circles without the use of instruments. A simple sketch of this kind might be much less accurate than the one shown and still meet all practical requirements, although if a neat and well-proportioned sketch can be made without special effort and unnecessary waste of time, it is certainly preferable. Besides, as pointed out before, a reasonable degree of accuracy is often essential. The outer circle or arc representing the outer ends of the gear teeth in Fig. 13 does not vary more than about 1/32 inch from a true arc on the original sketch, and it was drawn by the method previously described. When making a sketch of this kind, it is easy to locate the side view at the right by simply drawing light projection lines across from the end view.

If an arc of quite large radius is required, the elbow can be used as a pivot for the pencil, as demonstrated in Fig. 11. The elbow rests upon a table or desk and the pencil strikes an arc having a radius which is about equal to the length of the forearm. This method was employed for drawing the curved lines which form the body of the jack shown by the sketch Fig. 14. After drawing a center line and lines representing the top and base of the jack body, these arcs are struck and then it is easy to fill in the smaller details.

The Design of Small Machinery

A Description of the Requirements, General Methods Employed, and Some Novel Machines

By W. E. THOMPSON

SPECIFIC rules to govern the design of machines for producing work automatically are not feasible, for the reason that no set of rules or standard parts can be complete enough to cover more than a few cases arising in general practice, no two cases being worked out by exactly the same method of procedure. In view of the variety of methods and principles that may be used to obtain a given result, the application must necessarily become a matter of choosing the best one for each purpose, and in this selection is shown the individuality and versatility of each designer, since no two designers, working independently, arrive at the same conclusion in exactly the same way.

In brief, the general method employed is to plan the handling of the material through the various operations of the machine in their proper sequence, roughly sketch diagrams of the various movements that may be used, and choose the ones most suitable in the general combination. Enough views of the assembled machine must be drawn to illustrate clearly all of its working features; these drawings must then be checked at least twice by other designers and changed, if necessary, until a majority agreement as to the practicability of the design is reached; and finally the detail drawings and tracings must be made and checked at least once before they are sent to the shop to start actual production. In the case of a complicated machine, where doubt exists as to the manner of handling the problem, the suggested method should be tested experimentally to avoid carrying it to completion before finding it worthless for the purpose intended.

Some General Qualifications Necessary for Single-purpose Machines

Although it is not practicable to formulate standard rules governing the design of machines, as stated in the foregoing, there are some general qualifications that machines for work of a special nature must have in order to avoid trouble, and the following series of observations should be helpful in the design of such machines.

All machine parts should be designed so as to have a high factor of safety in order to withstand the greatest strain that may be thrown on them. For small strains, calculations are generally unnecessary, but when designing parts used for such work as the making of rivets, rolled thread screws, or heavy wire forming, the pressures needed should be calculated, or preferably measured when possible, and the working parts should be figured with a factor of safety of from 5 to 9, in order to overcome this resistance.

Slides should have their cross-sectional area and bearing length proportioned so as to avoid unnecessary friction or tendency to cramp; cams should be so designed as to avoid heavy strains on their driving mechanism; levers should be proportioned to obtain rigidity with subsequent uniformity of movement; and the general frame should be so designed as to withstand the strains applied to it by the various movements, without having excess weight. A practical knowledge of the construction and operation of successful machines for producing a similar class of work to that for which the machine being designed is intended is invaluable, thus eliminating much calculation when proportioning the details, by using such known parts as standards.

Movements should be made positive in cases where their failure to operate is likely to cause the machine to become inoperative. Springs or balance weights, which are employed as a means of performing a partial movement, are not positive and should not be depended upon if the action is vital to the proper functioning of the machine. In case they are used, however, provision should be made for disconnecting the driving mechanism as a means of insuring against breakage in case of failure to perform their function, and springs should be made long enough to avoid excessive overload being placed on them. Slides which are actuated by cams should preferably be operated in both directions by such cams, but where this is not necessary they should always have their working cycle cam-operated, or otherwise positively moved.

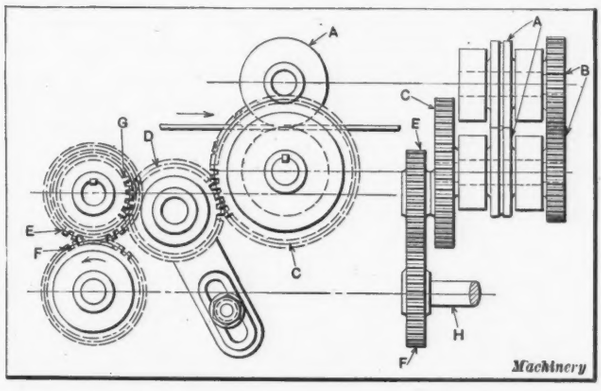


Fig. 1. Arrangement of Rolls and Gears on Wire-feeding Mechanism

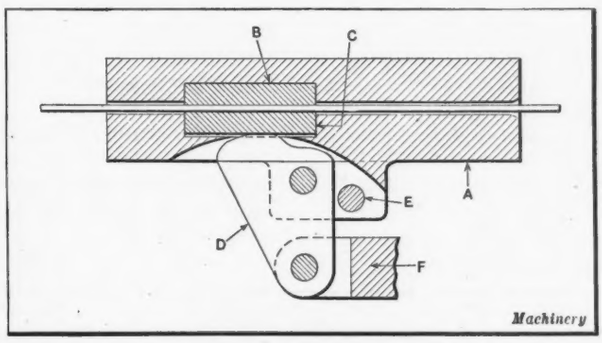


Fig. 2. Gripping Device for a Slide Wire-feed

The application of natural physical forces for performing work ought to be considered, as one or more may be employed in every machine. Some examples of the mechanical use of physical forces are: The application of atmospheric pressure and of friction for handling paper; the use of the force of gravity for assorting, separating, and feeding parts; combinations of heat and extreme cold for producing high vacuums; the application of light to extreme measurements; and the almost unlimited utilization of electricity.

Automatic feeding mechanisms and work-holding chucks should be carefully developed and should have an ample margin of strength for performing their particular functions. They should also be positively controlled and

locked, and the element of chance as affecting their movement should be eliminated to as great a degree as possible in order to avoid failure and the subsequent breakage of other parts of the mechanism.

Selection of the Proper Bearing Materials

The selection of correct bearing materials is often overlooked even in the redesign of standard machines, but special consideration should be given these parts, as being one of the most important factors governing the life of the machine. It is the customary practice to make the wearing surfaces of parts that have a sliding friction of two different materials, in order to reduce the natural property of adhesion. The most common combinations for use on machines which are to be operated by a varied class of workmen, and a combination which is least likely to suffer from lack of lubrication, consists of steel and a lead base material, or bronze and steel. In many cases the use of cast iron on cast iron is permissible, giving extreme durability at a low cost, but such bearings must have some form of continuous oiling arrangement to prevent adhesion of the surfaces. Cast-iron surfaces, after running a certain length of time, if well oiled, take a glaze that wears favorably as compared with hardened steel surfaces. Bearings made of steel—hardened, ground, and lapped—if well lubricated, give exceptionally long service and excellent results under close adjustment such as are needed in small lathes, screw machines, and high-speed grinding devices. For bearings that run continuously under medium pressure, where the use of oil is objectionable and where close adjustment is not a prime factor, steel or cast iron in combination with impregnated wood, gives wonderful results. A countershaft for driving light machinery, using steel and cast iron on impregnated wood is very serviceable; in fact the writer knows of a case where over two hundred such bearings have been running continuously without oil for about five years, without wearing loose or requiring repairs.

The use of fiber in bearings should be avoided, because the chemicals used in its manufacture have a deleterious action on such metals as steel or brass. The use of ball and roller bearings is often overlooked, but they should be employed wherever it is necessary to reduce the factor of inertia as much as possible. Ball and roller bearings have the lowest coefficient of friction of any commercial bearing, but they should be well lubricated, nevertheless, in order to obtain the maximum amount of service from them. In many cases, the size of such bearings for the capacity needed and the number of movable parts prohibits their use, but they are highly efficient where the design makes replacement a simple matter.

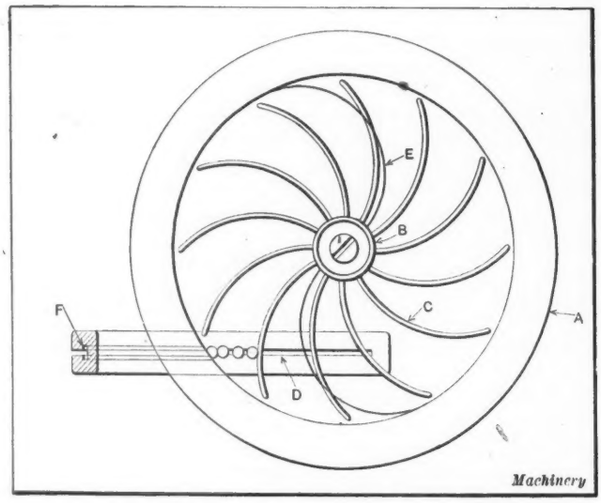


Fig. 3. Hopper for feeding Screws through a Chute

Feeding Mechanisms for Wire-bending Machines

Various movements are used for feeding wire, among which are rolls having an intermittent gear drive and slides in which the wire is locked during the feeding stroke and released during the return. The roll feed mechanism shown in Fig. 1 is used on a machine for cutting straight wire to length, and consists of two rolls *A*, having grooves on their faces in which the wire is held, the rolls being caused to rotate together by means of gears *B*. The upper roll may be adjusted for pressure by screws. Change-gear *C* is keyed to the lower roll shaft and is driven through the idler *D* by means of another change-gear *G*, which is keyed on the same shaft as intermittent gear *E*. An intermittent driving gear *F*, keyed to the main driving shaft, operates the feed and times it with the cut-off mechanism, which is operated by a cam on the same shaft. The rolls are at rest during the cutting-off period, which is very short, and the motion of the wire is nearly continuous. One objection to using a roll feed is the small arc of gripping contact which exists between the rolls and the wire.

Fig. 2 shows the gripping mechanism of a slide wire-feed such as is used on a wire-forming machine, which consists of a slide *A*, carrying two jaws *B* and *C*, between which the wire is held. The lever *D* is operated by a lever and cam through the link *F*. On the forward or feeding stroke of the machine, the lever *D* forces the lower jaw *C* into contact with the wire, and the greater the force exerted against the jaw, the tighter it grips. On the backward stroke, lever *D* is pulled away from contact with the gripping jaw, until it comes to a stop against a pin *E* in the slide, at which time the slide has returned to its starting position. The length of the gripping surface that may be obtained, makes the use of the slide feed desirable for hard wire that needs considerable pull through the straightener. When a slide is used, the wire is held during the return stroke either by the cutting-off jaws or by the straightening rolls.

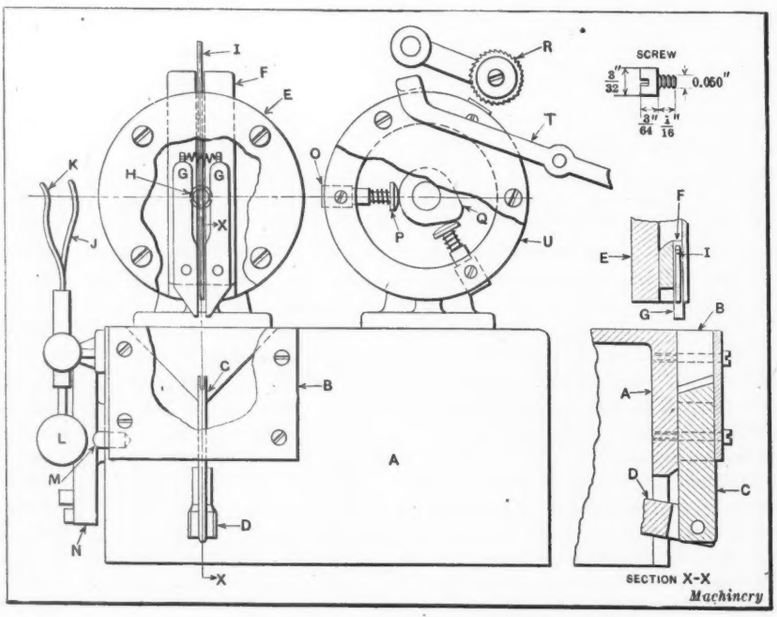


Fig. 4. Automatic Screw-feeding Mechanism for Special Screws

Hoppers for Screw-slotting Machines

The automatic separation of partly finished parts and their alignment into position for chucking is best accomplished by means of hoppers. Quantities of the parts are usually placed in a receptacle and means provided for agitating them continuously against the mouth of an opening in the side of the reservoir, the opening being just large enough to allow one piece to pass through at a time in the desired

position. Springs and brushes are commonly used in connection with this arrangement, but these have a tendency to force the parts into the opening in the wrong position and thus block it.

A hopper which is used to feed one type of screws is shown in Fig. 3. This consists of a stationary circular dish *A*, a rotary spindle *B*, to which is attached a series of curved spring arms *C*, set above the surface of the dish, a distance slightly greater than the height of the screw head, and two light spring arms *E*. The purpose of these arms is to stir the screws and to push them into the chute *F*. The chute is set into the bottom of dish *A* flush with its surface, so that the screws fall into slot *D*, in which they are supported by their heads. This type of hopper is satisfactory for screws in which the threaded part is heavier than the head, but is not suitable for very short screws.

An illustration of the hopper and the series of movements used in handling a very short screw is shown in Fig. 4. This arrangement illustrates an example of a machine having each separate movement protected against breakage caused by defective parts. The screw (which is shown in the detail view) has a head weighing more than the threaded part, and the natural tendency is for it to lie with the head down. Much trouble was experienced in trying to handle this work until it was discovered that the screws would stand upright in a close-fitting groove at an angle of 20 degrees from the horizontal, and a successful hopper feed was consequently made.

The screws are placed in a V-shaped reservoir *B*, attached to the machine base, in which a slide *C* reciprocates vertically. This slide passes down through the screws and on its upward stroke picks up at least two screws which slide to the lowest point of a groove cut in the top of the slide at an angle of 70 degrees with its edge and in which the shank of the screw fits loosely. The movement of the slide is controlled by a lever *D* and a cam on the main shaft. When the slide reaches the end of its upward movement, the screw head enters the lower end of the chuck jaws *G*, which are then closed on it by means of a tapered rod *H*, operated from a cam on the main shaft. These jaws are pivoted on a slide *F*, which is held up against a stop by a spring (not shown) on the under side. The drum *E* is then turned through 90 degrees, bringing the screw in line with holder *O*, at which time lever *J* pushes the slide forward until the threaded end of the screw enters this holder. Lever *K*, operating the rod *I*, then pushes the screw into its seat, the chuck jaws *G* having in the meantime been released. Both the levers *K* and *J* are operated by the cam *N*, and are made in the form of flat springs having a ball *L* at the lower end of each to return them to their normal position. One of these balls strikes intermittently, during a short period, against a pin *M* set in the hopper reservoir, and produces enough vibration to jar the screws and cause them to slide to the lowest point of the slide incline, those not in proper position falling off before reaching the chuck.

When the screw has been seated in holder *O*, the drum *U* is turned 120 degrees and locked; this brings the screw under the saw *R*, which then comes into action and mills the slot. During the next movement of the drum through 120 degrees, a knock-out *P* passes over the cam *Q* and the screw is ejected into a container. A brush is provided for removing loose saw chips, and a safety trip *T* releases the driving clutch when a screw having an extra long head passes under it, which prevents breakage of the saw. Both drums *E* and *U* are operated by cams through a rack and gear and are positively locked in their working positions. This type of hopper has given successful results, causing no trouble whatever. Should a screw lie across the top of slide *C* and be carried against the chuck it would simply push the chuck slide (which is held by a light spring) away from it and against a heavy spring stop. On the down stroke any screws not in the groove are knocked off by other screws, the only possible loss being one cycle of movements. In actual practice, the operation of the device is nearly continuous, the slide being nearly full of screws all the time, and a capacity of 3000 screws an hour may easily be obtained.

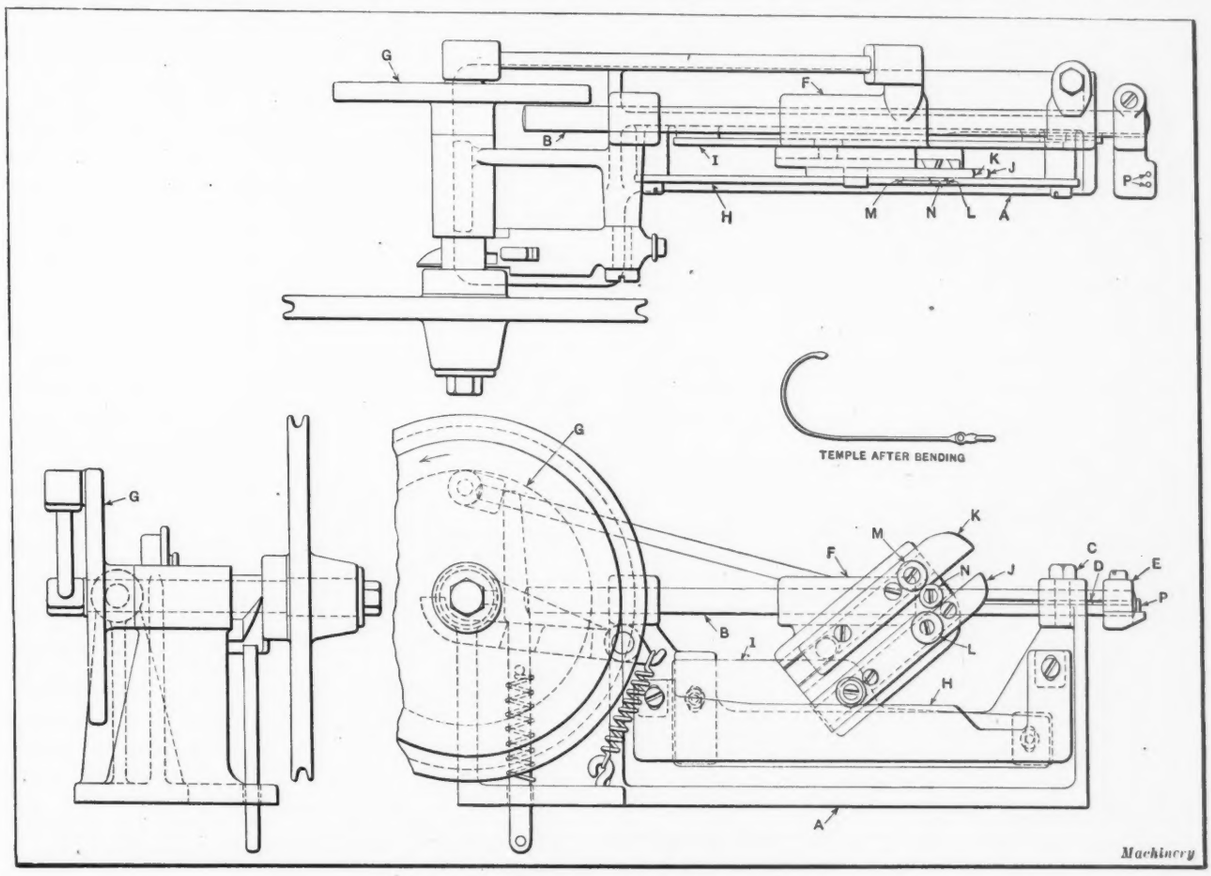


Fig. 5. Machine for bending Spectacle Temples

Design and Construction of Eyeglass and Spectacle Wire-forming Machines

Machines for forming wire of various cross-sectional shapes embody in their design a large variety of mechanical movements. Machines for making chain and wire mesh are particularly complicated, and those used for working wire parts for spectacle and eyeglass frames (two of which are to be described), also represent a high class of specialized design. In the evolution of machines of this type there are some general principles which are applicable, among which are the following:

The movements necessary to produce all the different bends in their proper sequence should first be planned and laid out. Each forming movement should have an individual adjustment, easily accessible, in order to obtain a uniform result from different coils of material, since it is practically impossible to obtain wire commercially, that has a uniform degree of temper. It is poor practice to design a forming surface to rub or drag on the metal; therefore provision should be made for a rolling contact or some movement that will form the wire with the least possible amount of slippage. A wire straightener that drags on the surface of the metal is not necessary and is objectionable—a series of rollers should be used instead.

Both rotary- and stationary-base straightening attachments are used on wire-forming machines, but the stationary base on which are mounted two sets of rollers, set at right angles to each other, is the less troublesome type on account of its simplicity. It requires more skill to set than a rotary head which has only one set of posts, but the stationary-head roller does not rub or drag on the metal, whereas the use of a rotary head necessitates making the wire-forming points of soft material, so as to prevent marking the highly finished surface of the wire, and these points become quickly worn. Wire that does not have a circular cross-section, must be straightened in a stationary-base attachment.

At one time spectacle temples, after assembling to the frames, were bent to conform to the ear by passing them through three fingers of the hand. This operation required considerable skill on the part of the workman and a number of different mechanical methods were employed in a certain plant to duplicate the hand-bent article, but without success until the machine shown in Fig. 5 was made. The working points of this machine have the same movement as the three fingers, but have the added advantages of mechanical uniformity and speed.

The machine consists of a frame *A*, in which is mounted a rod *B* which is adjustable longitudinally to suit different lengths of temples, being locked by a split bearing and a cap-screw *C*, and prevented from turning by a key *D*. The gage *E* is locked on one end of this rod. The part *F* is actuated by a crank and crank disk *G* and slides freely on the rod. Cams *H* and *I* control the movement of slides *J* and *K*, respectively. These slides move freely in the part *F* and are held in contact with the cams by gravity. The rollers *L* and *M* are carried on the slides and move in directions governed by the outlines of cams *H* and *I*. The roller *N* is attached to part *F* and moves horizontally only. A sliding key clutch connected with a foot-treadle, made so as to allow only one complete revolution of the driving shaft without releasing the foot, is used to actuate the machine. Part *F*, with the slides attached, is a sliding fit between the two cams *H* and *I*, which are secured to the frame, the elongated screw-holes allowing them to be adjusted vertically. The temple, with the end piece assembled, is inserted between the two gage-pins *P* and gaged against the surface of the slides, while lying in the groove of roller *N*. The three rollers, on the forward movement of the machine, close on the wire, thus producing a bending, wiping action that shapes the temple to the proper form. The temple is bent, partially straightened, and rebent, giving it a much more permanent set than could be obtained by the old hand method of bending.

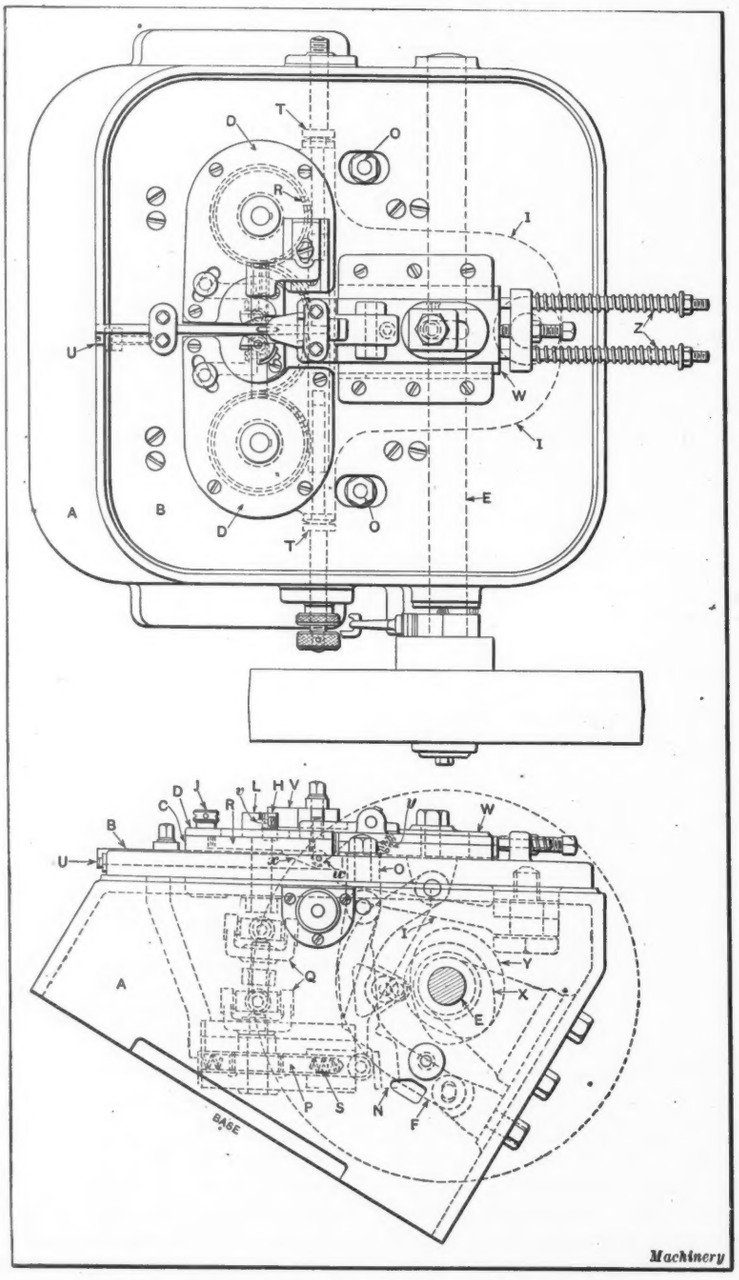


Fig. 6. Wire-bending Machine for forming Bridges for Eyeglasses

The nose pieces, or bridges, of eyeglasses and spectacles are commonly made from wire having an oval cross-section, but the highest grades are made by reducing the ends of round wire, previously cut to a uniform length, striking these blanks between press dies to form a thin wide section at the center, tapering to an oval section at each end, and then bending them to shape. In Fig. 6 is shown a plan and an elevation view of a machine for completely forming any shape or size of bridge, while Fig. 7 is an enlarged view of the forming mechanism employed in the machine. This machine consists of a base *A* on which are mounted the driv-

ing shaft *E*, lever *F*, and the cover *B*. Nearly all of the working parts of the machine are attached to the cover. It will be noticed that the machine has a sort of twin construction, and in all cases one reference letter will be sufficient to designate twin parts, regardless of which view is being referred to. Two arms, *I*, Fig. 6, are pivoted on the under side of the cover and are held apart and against stops *T* by means of a spring. These stops are adjusted by a knurled collar operating right- and left-hand screws on opposite ends of the machine, which are connected so as to turn together by a keyed sliding sleeve. The screws may be locked in position by means of a knurled nut. The swing arms *I* support the shank-forming anvils *L* (see Fig. 7), the rotative position of which is adjusted and locked by the bolts *J*. The shanks of these anvils pass down through plates *C*, attached to the swing arms, and form a bearing about which the two gear segments *K*, Fig. 7, may oscillate. These gear segments, to which are bolted the shank bending arms *M*, are oscillated through approximately 90 degrees in the following manner: Cams *Y* (shown in the side elevation, Fig. 6) operate the levers *N* which are pivoted adjustably on the studs *O*, in relation to the cover *B*. The levers operate a rack and gear *P*, transmitting motion through the universal joints *Q* to the gears *R*. The entire movement is positive on the bending part of its cycle, the parts being returned to their normal position by a spring *S* in each rack.

The gears and gear segments are held in place by the cover

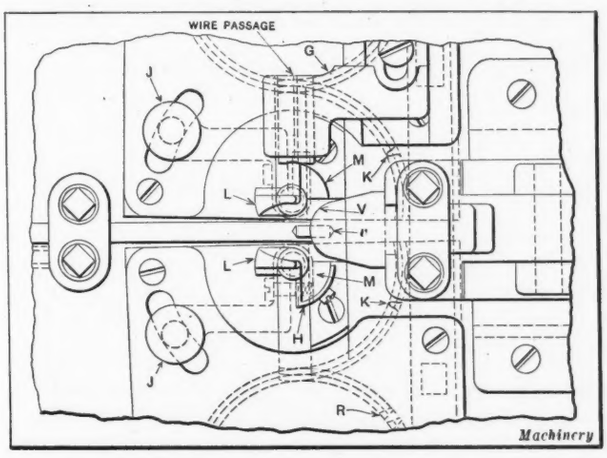


Fig. 7. Enlarged View of the Forming Mechanism employed in the Machine shown in Fig. 6

plates *D*, which also protect them from dirt, and to one of these is bolted an adjustable arm which supports a wire guide and cutting-off blade *G* (see Fig. 7). This arm may be adjusted in relation to one of the bending arms *M* which constitutes a cutting member when operating with the cutting-off blade. The interchangeable former *V* is clamped in an arm which is pivoted in the slide *W*, Fig. 6, the movement of which is controlled by cam *X*, lever *F*, and two springs *Z*, between which is an adjustable stop. The upper pivot of lever *F* is attached to a plate which has a sliding adjustment in *W*, and is provided with a series of graduations which enables this pivot to be readily set for different depths of bend. The adjustable stop against which the slide rests when in its normal position is regulated to hold the nose of the former *V* in line with the bending surfaces of the arms *M* (see Fig. 7). Each former *V* has a pin *v* driven into it, which normally extends under the wire to be formed. The arm which carries the former *V* has a cam roller *w* (see side elevation, Fig. 6) under it which is held against the adjustable cam *x* by a spring *y*. The adjustable cam is regulated by means of screw *U*, and its function is to cause the pin *v* to raise the wire as the former *V* bends it, and thus obtain the desired offset. The machine is driven by a flywheel which is equipped with a Horton clutch, so arranged as to return the foot-treadle to the starting position with every revolution.

Operation of the Bridge Forming Machine

The cycle of operations for making bridges of wire having a uniform cross-section is as follows: Referring to Fig. 7, the wire is fed by hand from a coil, previously straightened, through a passage in *G*, in which it is a sliding fit, until it comes to a stop against the gage *H* (see also Fig. 6). It passes between the forming surfaces of the bending arms *M* and the nose of former *V* on one side, and the points of the anvils *L* on the other side, resting on shelves formed on the small end of the anvils, thus gaging its vertical position. The machine first cuts off the wire and bends the ends around to points of the anvils *L*, locking it firmly while the former *V* comes forward and upward to make the nose bend and offset. After the operation is completed, all the parts return to their starting position and the bridge is removed by hand. When the former bends the wire between the points of the anvils, these points pivot on their respective swing arms *I* (shown in Fig. 6) until they bring the wire into close contact with the sides of former *V*. It is due to this swing, which is variable for different widths of bridges, that the universal joints *Q*, Fig. 6, are necessary in the operating mechanism. When bending bridges which have previously been cut off, and which do not have a uniform cross-section, the part *G* is removed and the bridge placed in position by hand, one end being held against the gage *H*. The cycle of movements is otherwise the same as described.

This machine has a capacity of 2000 pieces per hour. If the machine were equipped with an automatic feed no advantage would be gained over the hand feed, because these parts are generally carried through in small lots of many different sizes and shapes. It will be noticed that the top plate *B*, Fig. 6, is set at an angle with the base. This is for the purpose of placing the parts in the best working position, so that the workmen may plainly see to operate and place the pieces in the machine.

* * *

NATIONAL SAFETY CONGRESS

The National Safety Congress, held in Cleveland with headquarters at Hotel Statler, October 1 to 4, will be divided into sections representing, respectively, the automotive, cement, chemical, structural, metal, mining, woodworking, rubber, packing, paper and pulp, and textile industries, with special sections relating to steam and electric railroads, women in industry, employes' representation, Americanization, health service, public safety, public utilities, and marine and navigation. The papers to be read before the metal section, which are of particular interest to the readers of MACHINERY, were given in the September number of MACHINERY, page 91. Other papers that will prove of interest to manufacturers and executives engaged in the machinery and metal trades are those read at the employes' representation session, which are as follows: "Cooperation and Industrial Progress," by Cyrus McCormick, Jr.; "Experience of William Demuth & Co. in Industrial Democracy," by F. L. Feuerbach; "Practical Aspects of Employes' Representation," by E. B. Tolsted; "Employes' Representation from the Standpoint of Organized Labor"; and "Labor Management and Collective Bargaining," by W. M. Leiserson.

In connection with the congress, the most complete collection of commercial and non-commercial safeguards, appliances, devices, and accident prevention information ever arranged in the history of the National Safety Council will be shown at the exhibit to be held at Gray's Armory, in Cleveland. There will be seventy booths in which will be shown types of safety equipment for every industry.

* * *

When equal parts of copper and antimony are melted together, an alloy of a beautiful violet color is formed which takes a nice polish, but as it is too hard for many purposes, a substitute can be produced by copper-plating an iron casting, and then immersing it in a solution containing antimony.

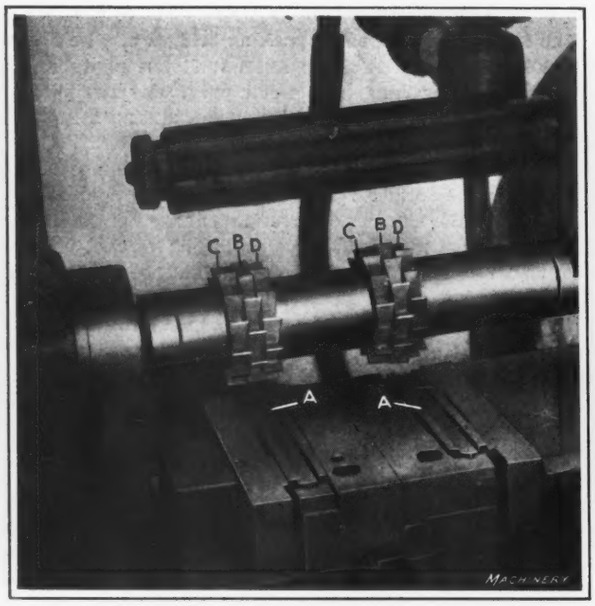


Fig. 1. Rough- and finish-milling Base of Back Sight Beds for Guns on 8-inch Automatic Milling Machine

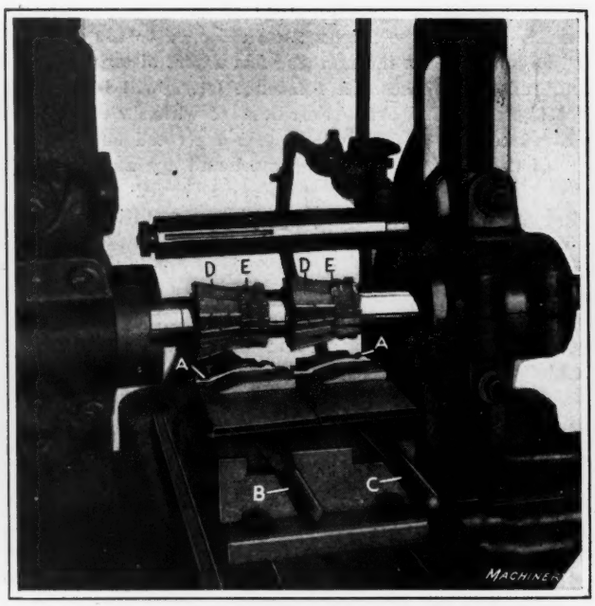


Fig. 2. Rough- and finish-milling Formed Top of Back Sight Beds for Guns on 12-inch Automatic Milling Machine

Production Milling on Automatic Machines

Second of Two Articles Describing Advanced Practice in the Milling of Duplicate Parts

By EDWARD K. HAMMOND

IN shops where large numbers of relatively small duplicate parts require milling operations to be performed on them, automatic milling machines built by the Pratt & Whitney Co., of Hartford, Conn., give very satisfactory service from the standpoints of rates of production and accuracy of the finished work. These millers have been evolved from the Lincoln type of milling machine, and they are equipped with an intermittent table feed and fast traversing mechanism, and an automatic quick return for the table. All of these table movements are controlled by means of adjustable tripping dogs that are mounted on a plate which is conveniently located at the front of the machine. With this arrangement for controlling the table, provision is made for having the work approach the cutter at the fast traverse speed, and when the cutter is about to engage the work, the regular rate of feed is automatically thrown into operation. After the cut has been completed, the direction of table movement is automatically reversed and the table is rapidly traversed back to the starting position. While returning to the starting point, the table is automatically lowered in order to prevent the milling cutters from dragging over the work and marring its finished surface; and at the end of the return movement, the table is automatically raised to the cutting position. This receding movement of the table is accomplished without impairing the rigidity of the supporting members or accuracy of the table movement.

By having the feed and traverse movements of the table automatically controlled, the amount of non-productive time of the machine is substantially reduced. The operator's work is also greatly simplified, as he is merely required to remove milled pieces from the work-holding fixture and set up fresh blanks in their places. As a result, one man is able to look after several machines, the exact number being dependent upon the length of time required to complete a single operation. Another case in which the automatic table control proves of value in reducing production costs is for milling work on which there are several lugs or bosses to be machined, which are spaced some distance apart, or where a number of small parts are set up at intervals along a string fixture. In such cases, the intermittent feed arrangement permits the table to be rapidly traversed from one cutting position to another, thus greatly reducing the machining time. In its loading position, the table must also carry the fixture far enough away from the cutters to permit the work to be easily set up, and the power rapid traverse then permits the table to be advanced quickly to its cutting position. In fact, the general statement may be made that to obtain the highest rate of production on these machines, the feed movement of the table should only be used during the actual cutting period; at all other times, the fast traverse is employed. Pratt & Whitney automatic milling machines are made in four different sizes with a table traverse of 5, 8, 10, and 12 inches, respectively. Each size of machine is furnished with a range of spindle speeds and rates of feed that are suitable for all classes of work that will be done on a machine of this size. In many

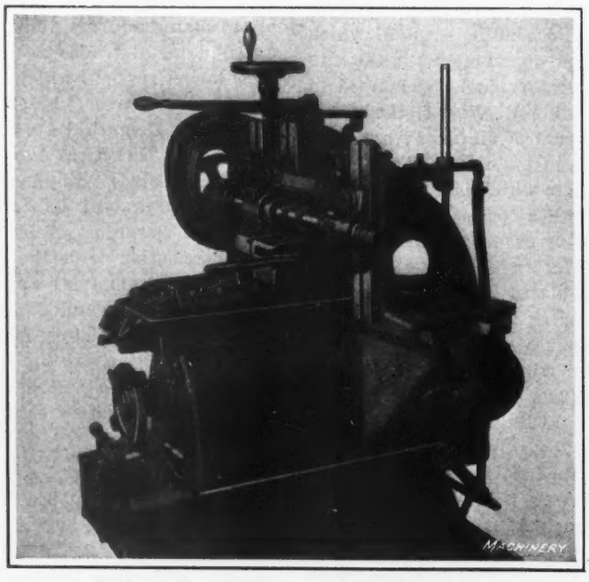


Fig. 3. Eight-inch Automatic Milling Machine for rough- and finish-milling Base of Back Sight Beds for Guns

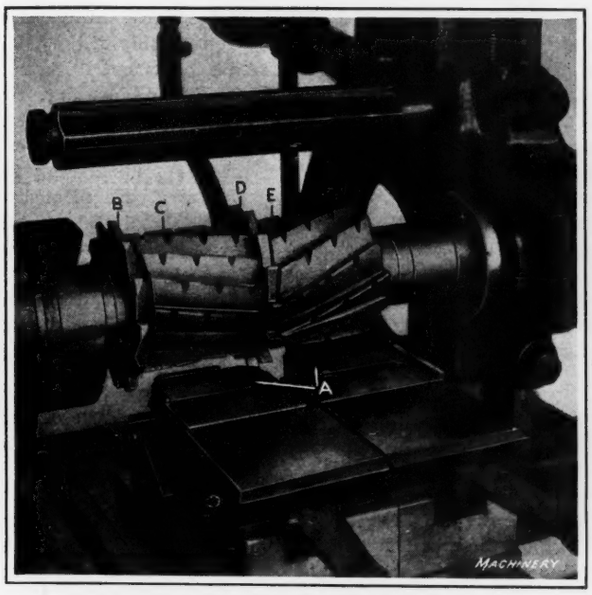


Fig. 4. Twelve-inch Automatic Milling Machine milling Top, Bottom, and Ends of Back Sight Leaf

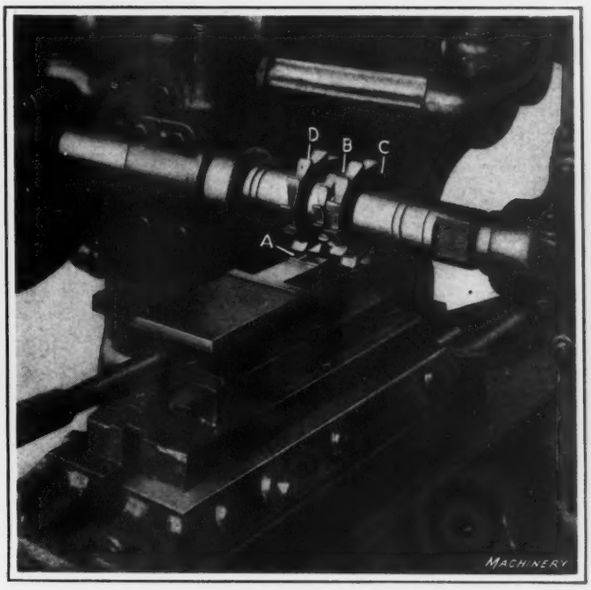


Fig. 5. Five-inch Automatic Milling Machine facing Ends and milling Groove in Back Sight Leaf Slide

plants, a machine adjuster, who is a skilled mechanic, is made responsible for the setting up and sharpening of cutters used on anywhere from twenty to thirty machines, while the machine operator is a semi-skilled man who may be trained quickly to perform his part of the work. During the last few years, girls have been successfully employed as operators of these machines.

Work-holding Fixtures for Automatic Millers

As in the case of work-holding fixtures used on other types of machines, there are several general principles which must be adhered to in making fixtures for holding the work on automatic millers, if the maximum production is to be secured. The two following are most essential: First, in order to obtain accurate results (and if accuracy is a requirement, it must be secured at any cost) the work must be held solidly and rigidly. Second, in order to obtain the maximum production, the fixture must operate rapidly. As far as possible, all of these milling fixtures should be so designed that they are locked and unlocked by a single movement of an operating handle. To carry this principle out in practice often imposes a difficult task upon the tool designer, yet, with but few exceptions, it may be successfully accomplished. In many cases, it will undoubtedly add to the cost of the fixture, yet it becomes a paying investment if a great number of pieces are to be machined. The fixture is made only once; but it is operated every time a part is milled. Therefore, if the expenditure of an extra hundred hours of work in making the fixture will save a thousand hours in production time, the economical solution of the problem of fixture design is to add this time to the making of the fixture.

For holding a large variety of small sized pieces of work to be milled, a very satisfactory and inexpensive work-holding fixture is made by applying special jaws to a standard milling machine vise. The Pratt & Whitney Co. has developed a line of quick-action manufacturers' vises which carry out the two basic principles stated previously; namely, rigidity and quick operation. These are made in both single and double types. In the case of the double vises, the position of one vise is made adjustable, so the work in either vise can be independently set up in relation to the cutters.

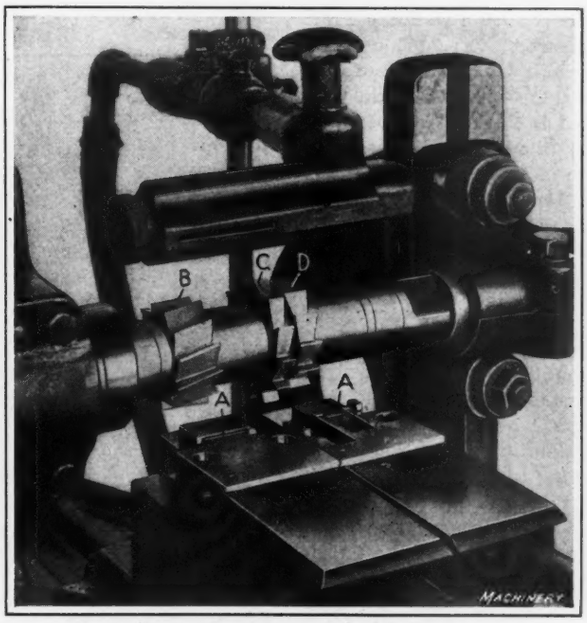


Fig. 6. Five-inch Automatic Milling Machine milling Top, Side, and End of Back Sight Leaf Slide Dog

Grouping Milling Operations According to Time Required to Perform Them

In order to secure the maximum production, where one operator handles several automatic milling machines, great care must be exercised in grouping the operations. The actual machining time of the operations handled by one man should be the same as or even multiples of each other. To make this point clear, suppose there are several milling operations which it is desirable to group. The time per operation on the first is three minutes; on the second, four minutes; on the third, eight minutes; and on the fourth, nine minutes. If there are a sufficient number of parts requiring any one of these operations to be performed on them, to keep one man busy, the planning department would naturally group them together. If not, the next best method is to group three of the three-minute operations with one requiring nine minutes; and two of the four-minute operations with one requiring eight minutes. In this way, it will be possible to maintain the maximum rate of production. In many cases, the variety of milling operations to be performed is so small that it does not leave a wide choice in grouping. Under such conditions, the grouping should be arranged to reduce to a minimum lost time of both the operators and the machines. In cases where maintaining rates of production is of paramount importance, the machines should be kept busy, even at the cost of an excessive amount of idle time of the operators.

Automatic Miller Equipped for Rough- and Finish-milling Operations

Fig. 3 shows an 8-inch Pratt & Whitney automatic milling

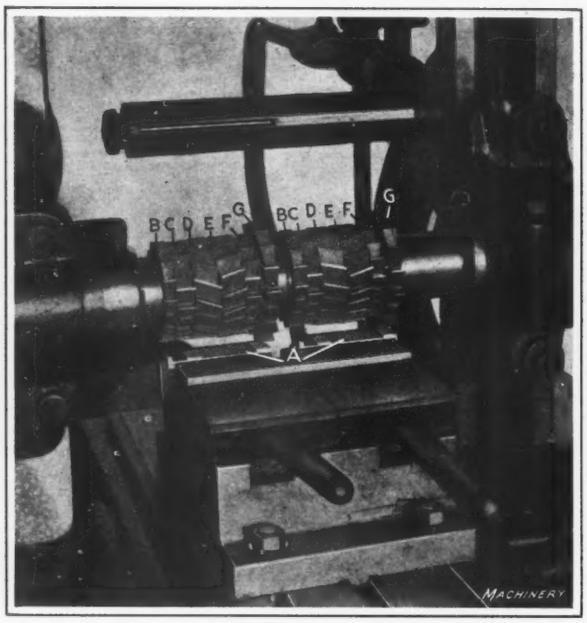


Fig. 7. Twelve-inch Automatic Milling Machine rough- and finish-milling Nine Faces on a Follower

machine equipped to provide for rough- and finish-milling the base and groove of a gun part known as a "back sight bed." Fig. 1 illustrates the cutters, work-holding fixtures, and pieces *A* to be milled, in greater detail. In performing this milling operation, a roughing cut is first taken on the work held in the left-hand fixture; and after this has been done, the rough-milled part is transferred to the right-hand fixture, in which it is held while the finishing cut is taken. It will be apparent that after the rough-milled part is placed in the right-hand fixture, a fresh blank will be set up in the left-hand fixture, so that for each traverse of the milling machine table, one finished part will be obtained. If the desired rate of production were greater, a similar set-up could be employed, except that two roughing operations would be performed on one machine and two finishing operations on another. With such an arrangement, two pieces would be secured for each cycle of movements of the milling machine table. It will be quite evident from Fig. 1 that there are two gangs of similar cutters used for performing the roughing and finishing operations on these parts. Cutter *B* mills the groove in the work, and cutters *C* and *D* mill the surface at either side of the groove. The work-holding fixture consists of special jaws mounted in a standard Pratt & Whitney quick-action manufacturers' vise. This work-holding fixture is operated by a single motion of the clamping handle, thus greatly reducing the non-productive time of the machine. The cutting speed is 65 to 75 feet per minute, with a feed of 2.14 inches per minute. The pieces *A* to be milled are made of steel. The actual cutting time is 2 minutes 10 seconds per operation, and the loading and unloading time is 37 seconds, making the total operating period 2 minutes 47 seconds. One operator is able to take care of a group of three machines working on this job.

Rough- and Finish-milling Work to Desired Contour

Fig. 2 illustrates a 12-inch Pratt & Whitney automatic miller set up to rough- and finish-mill the top of back sight beds for guns, and shows clearly the cutters, work-holding fixture, and the form to which parts *A* have to be milled. As in the case of the rough- and finish-milling operation which has just been discussed, the roughing cut on the present job is taken with the work held in the left-hand fixture; and after this preliminary operation has been performed, the work is reset in the right-hand fixture ready for the finish-milling operation. At the time each piece is finish-milled at the right-hand side of the table, another piece is rough-milled at the left-hand side, so that one piece is finished for each cycle of table movements. The work-holding fixture consists of special jaws applied to a standard milling vise; and to clamp or release the work at either side of the table, it is merely necessary to give a single movement to lever *B* or *C*. To provide for obtaining the desired contour, two gangs of milling cutters are mounted on the arbor, each gang consisting of two cutters *D* and *E*. It will be seen that cutters *D* are angular mills which provide for finishing the inclined face of the work, while cutters *E* are formed to produce the desired contour at the right-hand end of each piece. On this job, the cutting speed is 73 feet per minute, and the feed is 1.86 inches per minute. The actual cutting time per piece is 1 minute 11 seconds, and the loading time is 40 seconds, making the total time per operation 1 minute 51 seconds.

Machine Equipped for Milling Top, Bottom, and Ends of Work

In producing the back sight leaf for a certain type of gun, it is required to finish the top, bottom, and both ends of the work. Fig. 4 shows a 12-inch Pratt & Whitney automatic miller which is equipped for performing all of these operations. At the left-hand side of the machine there is a fixture in which the work is held to allow the top and both ends of the work to be milled; and after this cut has been completed, the piece is transferred to the fixture at the right-hand side of the milling machine table, in which it is held while the bottom of the work is being milled. The fixtures consist of standard vises equipped with special jaws; and each of the two vises can be tightened or loosened by manipulating a single handle. These gun sight leaves are machined from bar stock 13/16 inch by 1/2 inch in cross-sectional area by 3 1/2 inches in length. A gang of three cutters *B*, *C*, and *D* is employed for performing the first operation. The angular mill *B* finishes the inclined left-hand end of the work, and the plain mill *C* faces off the top, while the narrow side milling cutter *D* finishes the right-hand end of the work. Cutter *E*, which performs the second operation, is not fully shown in Fig. 4. From this illustration the impression would be gained that this is a plain mill, but at its right-hand end, this cutter has an angular face which provides for milling the inclined shoulder at the right-hand end of the work. The cutting speed is from 80 to 95 feet per minute, with a feed of 1.22 inches per minute. The actual machining time is 1 minute 58 seconds, and the loading and unloading time is 43 seconds, making the total production time per operation 2 minutes 41 seconds. On this job, the operator looks after a group of two machines.

Milling Ends of Work and a Groove in the Top Face

To provide for simultaneously milling both ends and a groove in the top face of a gun part known as the "back

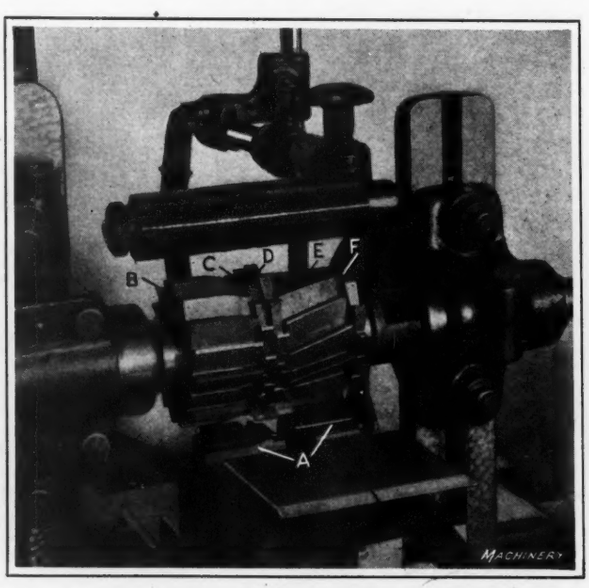


Fig. 8. Eight-inch Automatic Milling Machine milling Top, Bottom, and One End of the Forging for a Lower Band Spring

sight leaf slide," a 5-inch Pratt & Whitney automatic milling machine is used, which is equipped as shown in Fig. 5. The piece *A* to be milled is made from bar stock 3/8 by 9/16 inch in cross-sectional area by 1 1/8 inches in length. In this case, the work-holding fixture provides for setting up only one piece for the milling operation. This fixture has a pair of special jaws mounted in a single quick-action vise of standard design. The arrangement of milling cutters is quite simple. It consists of a gang of three side mills, cutter *B* being utilized for producing the shallow groove in the work, while cutters *C* and *D* face off the ends. On this job, the cutting speed is 80 to 105 feet per minute with a feed of 1.18 inches per minute. The machining time per cut is 1 minute 39 seconds, and the loading time is 27 seconds, making the total time per operation 2 minutes 6 seconds. One operator handles three machines working on this job.

Milling Top, Side, and End of Work

Fig. 6 shows another 5-inch size of Pratt & Whitney automatic milling machine, this tool being equipped to provide for milling the top, one side, and one end of a gun part known as a "back sight leaf slide dog," which is shown at *A*. A facing cut is taken on the top of this piece, while it is held in the fixture at the left-hand side of the machine, and both the end and a groove in one side are milled with the work held in a fixture at the right-hand side of the table. The work is held in a standard double milling vise provided with special jaws. It will be apparent from the illustration that a plain milling cutter *B* provides for taking a facing cut on the top of the work, while a gang of two cutters *C* and *D* performs the second operation. Cutter *C* faces off the end of the work, while cutter *D* mills the groove in the side. This job is performed with a cutting speed of 95 feet per minute, with a feed of 1.18 inches per minute. The actual machining time is 57 seconds, and the loading time is 33 seconds, making a total production time of 1 minute 30 seconds. This cut is so short that the operator is only able to handle a single machine.

Rough- and Finish-milling Work to Desired Form

On the 12-inch Pratt & Whitney automatic milling machine shown in Fig. 7, it will be seen that two gangs of six cutters each are utilized for rough- and finish-milling a gun part *A* known as a "follower," which must have the form shown in this illustration. As in preceding cases, the roughing operation is performed with the work held in the left-hand fixture, and the finishing operation with the same piece in the right-hand fixture. The method of setting up the work is also the same as that previously described, so that one finished

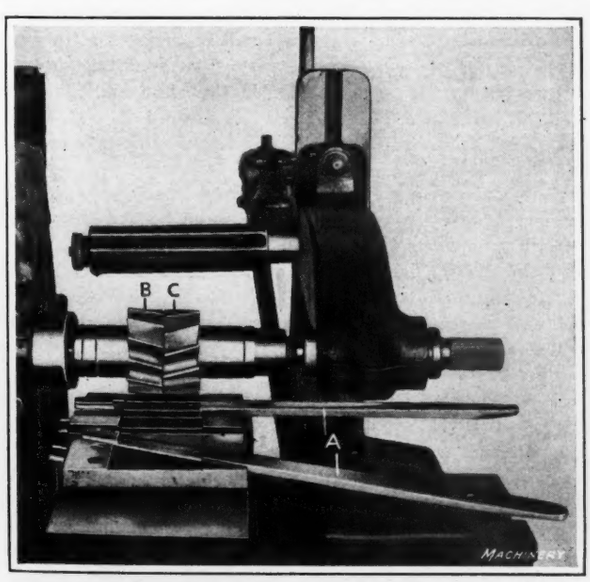


Fig. 9. Eight-inch Automatic Milling Machine milling the Non-parallel Sides and Bottom of the Lock Groove in a Bayonet

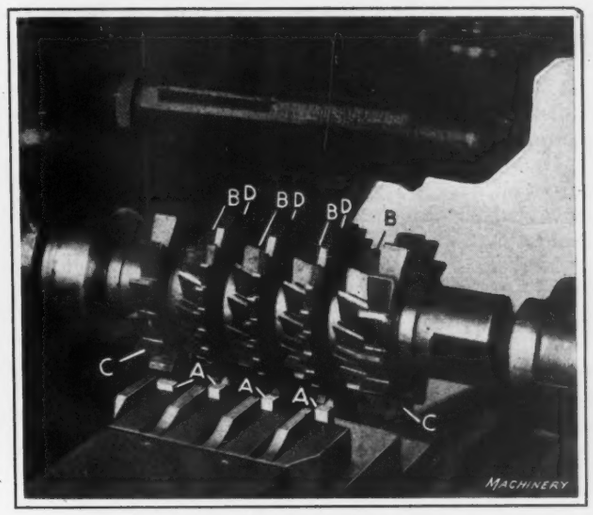


Fig. 10. Five-inch Automatic Milling Machine milling Top and Ends of Four Bayonet Locking Bolts, and cutting them off from the Bar of Stock

piece is produced for each cycle of table movements. It will be evident that each gang of cutters consists of six mills *B*, *C*, *D*, *E*, *F*, and *G*, each of these cutters being made of the proper diameter to mill one face of the work in the correct relative position to other finished surfaces. Cutter *G* is of sufficient size so that it overhangs the end of the work and provides for milling it at the same time that the five top faces of the piece are machined. These followers are made from steel bar stock 7/16 by 7/8 inch in cross-sectional area by 3 1/2 inches in length. The cutting speed is 69 to 89 feet per minute with a feed of 1.86 inches per minute. On this job, the actual machining time is 1 minute 51 seconds, and the loading time is 1 minute 8 seconds, making the total production time per operation 2 minutes 59 seconds. One operator is able to handle two machines working on this job.

Milling Top and Bottom Faces and One End of a Forging

The part shown set up on the 8-inch Pratt & Whitney automatic milling machine in Fig. 8 is a lower band spring for a gun. This part is made from a forging, and it is required to mill the top and bottom faces and one end of the work. It will be apparent from the illustration that the bottom face of work *A* must be machined to an irregular contour, and to obtain this result, a gang of three cutters *B*, *C*, and *D* is used. Cutter *B* is formed to correspond with the irregular contour of the curved section, while cutters *C* and *D* provide for milling the square shoulder and the end of the work, respectively. After this cut has been completed, the work is placed in the right-hand fixture and two cutters *E* and *F* are utilized for facing off the flat surface of the work and for straddle-milling the wall at the right-hand end. The cutting speed on this job is from 73 to 85 feet per minute, with a feed of 1.86 inches per minute. The actual machining time per operation is 1 minute 24 seconds, and the unloading and loading time is 53 seconds, giving a total production time per operation of 2 minutes 17 seconds. Sufficient time is allowed by the cut to enable one man to operate two machines working on this job.

Milling a Slot with Non-parallel Sides

An interesting operation is shown in Fig. 9, which consists of milling the non-parallel sides and bottom of a slot in the end of a bayonet, to receive the locking bolt. Two pieces of work *A* are set up in the fixture, one behind the other, in such relative positions that one side and part of the bottom of the slot are milled in the first piece; and when the second piece is carried up to the cutter, the opposite side and remainder of the bottom of the slot are milled. Two plain cutters *B* and *C* are used in order that the spiral angles of the teeth may be opposed to each other to neutralize the end thrust; otherwise, a single cutter could just as well be employed. After each traverse of the table, the partially milled

piece is removed from the first station of the fixture and reset in the second position. A fresh blank is then set up in the first station. With this arrangement, it will be evident that one piece is completely milled at each cycle of movements of the milling machine table. The construction of the fixture used for performing this operation is shown in Fig. 11. It has a clamping mechanism that is operated with a single cam lever *A*, the cam being attached to a sliding member *B*, and acting against a sliding block *C*. This results in drawing back the sliding member *B* and pushing forward block *C*. Sliding member *B* carries a jaw at the front of the fixture, and the rear jaw *E* is operated through a rocker arm *D* which is actuated by sliding block *C*. With this arrangement, the single clamping lever provides for securing both parts under an equal pressure. It will be noted that, in both positions, the work is held by fixed jaws acting against the cutter and clamped from the front. Attention is also called to the fact that there is a solid metal support under the cutter in both positions where the work is held. Thus, the maximum rigidity is secured for the fixture. On this job, the cutting speed is 67 feet per minute with a feed of 1.86 inches per minute. The actual machining time is 2 minutes 58 seconds, and the unloading and loading time is 1 minute 14 seconds, giving a total production time for this operation of 4 minutes 12 seconds. One operator looks after two machines engaged on this job.

Milling Top and Ends of Four Pieces of Work and Cutting them off the Bar

Fig. 10 shows a 5-inch Pratt & Whitney automatic milling machine equipped to mill the top and ends of four bayonet locking bolts *A* which are made from a single piece of bar steel 5/16 by 5/8 inch in cross-sectional area, by 4 1/4 inches in length. The work-holding fixture used for this job consists of a quick-acting vise, provided with special jaws and equalizing clamps operated from a single cam. A double "whiffletree" construction is employed for operating the equalizing clamps, which holds each part under an equal pressure, so that there is no danger of the work sliding at the time it is cut off. It will be seen that a gang of nine cutters is required for the performance of this operation. Four plain cutters *B* mill the sides of the shoulders and face the surfaces to the right of the shoulders. Two side milling cutters *C* face the ends of the work, and three cutting-off saws *D* divide the single blank into the four parts which are required. On this job, the cutting speed is 90 to 116 feet per minute, with a feed of 0.87 inch per minute. The actual cutting time is 2 minutes 1 second, and the unloading and loading time is 36 seconds, making the total time per operation 2 minutes 37 seconds. One operator is able to attend to two machines working on this job.

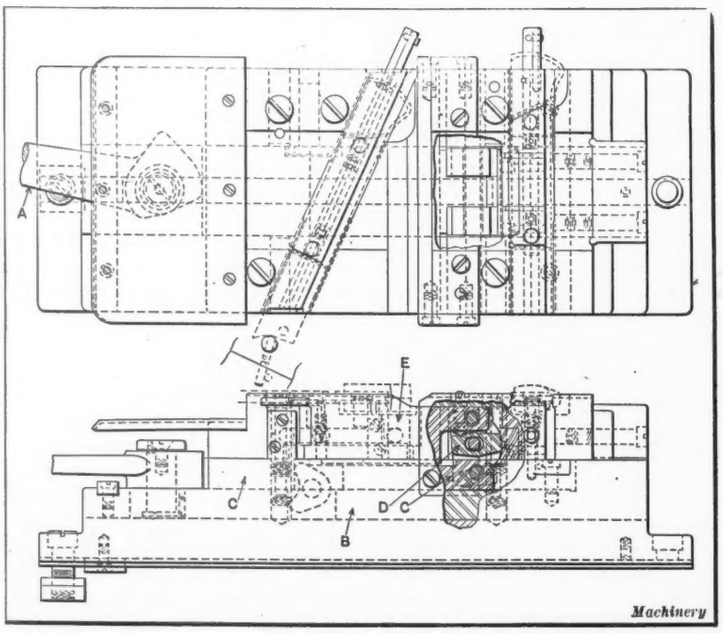


Fig. 11. Design of the Work-holding Fixture used on the Machine shown in Fig. 9

* * *

Bulgaria is now represented in the United States by a commercial commission which is here to undertake the re-establishment of trade relations. Bulgaria's first need is for food. Clothing, shoes, cotton, and petroleum are next in demand. With these primary needs fulfilled, Bulgaria will be in the market for manufactured articles.

THE BUREAU OF STANDARDS' WORK ON TOLERANCES

In connection with its work on tolerances and limits, mentioned in an editorial in the September number of MACHINERY, the Bureau of Standards has sent out a questionnaire regarding tolerances to a large list of manufacturing organizations requesting information upon the following points:

1. If you are establishing tolerances on your work in accordance with a system or table of allowances and limits for various kinds of fits, a copy of such table is desired.

2. For each class of work or machine that you manufacture, what tolerances are applied to the dimensions of fitted parts? This information may be transmitted by blueprints.

3. In assigning tolerances to parts, do you take the hole as basic or the shaft?

4. Are tolerances given on drawings rigidly adhered to, or are they exceeded, and to what extent?

5. How do you express tolerances on component drawings? (For example: $0.675 \begin{smallmatrix} +\ 0.006 \\ -\ 0.000 \end{smallmatrix}$ or $\frac{0.681}{0.675}$ or 0.678 ± 0.003, or by some other system?)

6. In general, to what accuracy are you able to do work on various standard types of machine tools such as lathes, milling machines, grinders, shapers, etc.? If you have used any non-ferrous metals, to what accuracy can they be worked?

7. In ordering machine tools, what accuracy do you specify on such items as feed- and lead-screws, gears, etc.? Or if you are a manufacturer of machine tools, what accuracy do you guarantee?

8. If you buy your parts, either finished or partly finished, do you specify the limits to be used, or does the manufacturer of the part set his own limits to work to?

9. To what extent are the parts of your machine interchangeable?

10. To what extent do you conduct inspection in your plant? Information as to the inspection facilities and organization, system of inspection in the shop and assembly room, extent of use of gages, etc., is desired.

11. Do you permit the inspector to use larger tolerances than the workmen?

12. Do you attempt to have the gages used by the workman within the limits of the gages used by the inspector?

13. Do you conduct inspection to obtain interchangeability, and what other objects do you endeavor to attain by your inspection system?

14. What relation is maintained between the tolerances permitted in the manufacture of your gages and the tolerance on the part to be gaged?

15. What tolerances or allowances, if any, do you make for parts that will work under high temperatures?

16. In the case of shrink, press, and drive fits, do you modify the allowance for differences in length of contact? That is, should the allowance on the diameter for a hub 6 inches long be the same as that for a hub 1 inch long?

17. Are you as a manufacturer interested in these points?

Replies should be forwarded to the Gage Section, Bureau of Standards, Washington, D. C.

Die-Casting and Die-Casting Metals

An Article Describing the General Organization of a Plant for Making Die-molded Castings, and Reviewing the Metals Now Commercially Used in Die-casting Practice—Based upon the Experience of, and the Methods Used by, the Stewart Mfg. Corporation, Chicago, Ill.

By ERIK OBERG

SEVERAL years ago, a number of articles were published in MACHINERY dealing with what was then a new development in the metal industries—the art of die-casting. The machines and methods used in the early development of this new industry were described, and the metals that, up to that time, had been found most suitable for die-casting purposes were reviewed. Since that time, the industry has made enormous strides; semi-automatic and automatic machines have replaced the early hand-operated types; large factories have sprung up devoted entirely to the manufacture of die-castings, and an entirely new industry of large ramifications has been created. It is the object of the present article to describe the general organization of one of the most modern of these die-casting factories, built by the Stewart Mfg. Corporation, Chicago, Ill., in 1918, as a description of this company's plant and methods will provide a general idea of the remarkable development that has taken place in the die-casting industry in the last ten years.

Plant of the Stewart Mfg. Corporation

The heading illustration shows a view of the new plant of the Stewart Mfg. Corporation. This plant covers an area of 300 by 300 feet, the office building being two stories in height while the main factory building is of one-story, sawtooth roof construction. The floor plan of the factory is shown in Fig. 2, this floor plan indicating what a die-casting plant comprises and the various departments required in a complete plant making die-molded castings. By reference to the illustration, it will be seen that the plant is divided mainly into nine departments as follows:

1. *Melting Department*—In this department the various metals used are compounded or mixed and then cast into ingots which are subsequently remelted in the casting machines.

2. *White Metal (White Brass) and Aluminum Die-casting Department*—This department is the main die-casting department of the factory and may be considered the principal department as far as the product is concerned.

3. *Inspection Department*—There are two inspection departments—one in which the castings are inspected when coming from the casting department, and one in which the final inspection takes place previous to shipping. The first of these departments, as will be seen, is located next to the die-casting department, while the other is located in immediate proximity to the shipping room.

4. *Cleaning Department*—In this department the die-castings are cleaned by the removal of fins, and other finishing operations for which machine tools are used are performed.

5. *Plating Department*—Such die-castings as require a fine outside finish are nickel-plated (or brass-plated) in this department.

6. *Polishing Department*—The plated die-castings are polished here in order to improve their appearance.

7. *Yellow Brass Die-casting Department*—The recent development in the die-casting of brass and bronze has necessitated a special department for the making of die-castings from these materials.

8. *Tool-room*—The tool-room in a die-casting plant is one of the most important and one of the largest departments, because of the great number of dies that are required for the different castings to be made.

9. *Machine Shop*—The Stewart Mfg. Corporation builds all of its own die-casting machines, and hence a machine shop of

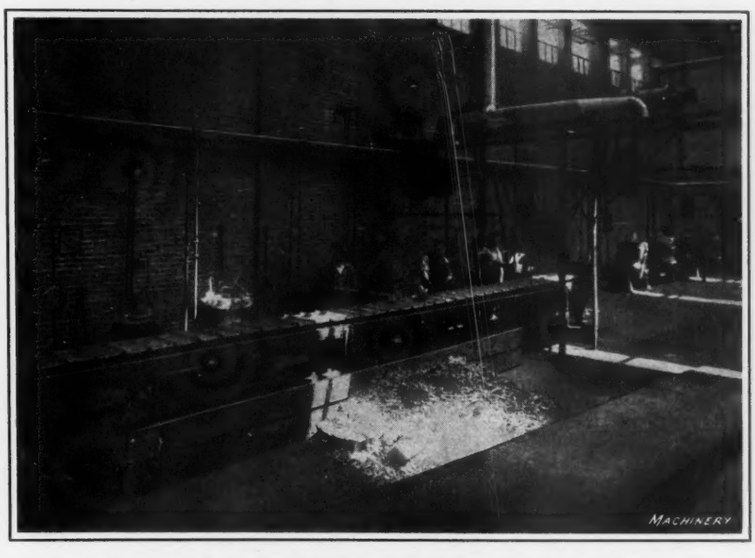


Fig. 1. A General View of the Melting Room where the Various Metals used in the Die-casting Machines are alloyed

considerable proportions is required for the making of these machines and for keeping them in repair.

In addition, an extensive engineering department is required for the designing of dies and special tools and for the development of improvements in, or the design of, entirely new die-casting machines.

The Melting Room

The original metals are bought in their commercial form by the company and are melted and alloyed in a separate melting room, a view of which is shown in Fig. 1. Molds for casting the ingots are here provided in the form of an endless chain conveyor, as shown. The metal is poured into these molds, and as the conveyor moves toward the right, it will throw the ingots, which have solidified by the time they arrive at the end of the conveyor, on the floor. From here, the ingots are taken to the die-casting room where they are remelted in the melting pots of the machines as required.

A most important part of the work, both in alloying and in remelting, is the temperature control. During the alloying, the metal is mechanically stirred to insure proper mixing. The temperature is recorded for each melting furnace on a recording pyrometer. There is one recording instrument for every two melting furnaces, so arranged as to give one record for each. The chief chemist examines the charts from the recording instruments which are sent to him daily, and in that way, proper control of the melting temperatures and, in consequence, of the die-casting metals is possible. The temperature control at the die-casting machines is made in the same manner, there being one pyrometer to every two machines. The shipments of raw material received are also analyzed to make sure that the proper metals are being used.

Equipment of the Die-casting Rooms

The die-casting department is divided into sections by sheet-steel partitions, and similar partitions are also placed between the individual machines in each section or battery, as shown in Fig. 3, which gives a good idea of the arrangement of the machines in rows, much the same as would be the arrangement in a regular machine shop. The melting pots are heated by gas, and many of the machines are pneumatically operated, which accounts for the great amount of piping seen in the illustration. The die-casting room is equipped with one hundred twenty-five die-casting machines of different types, according to the work for which they are intended. Altogether, there are five specific types employed.

First, there is the standard line of Stewart die-casting machines employed for white-metal and bearing-metal cast-

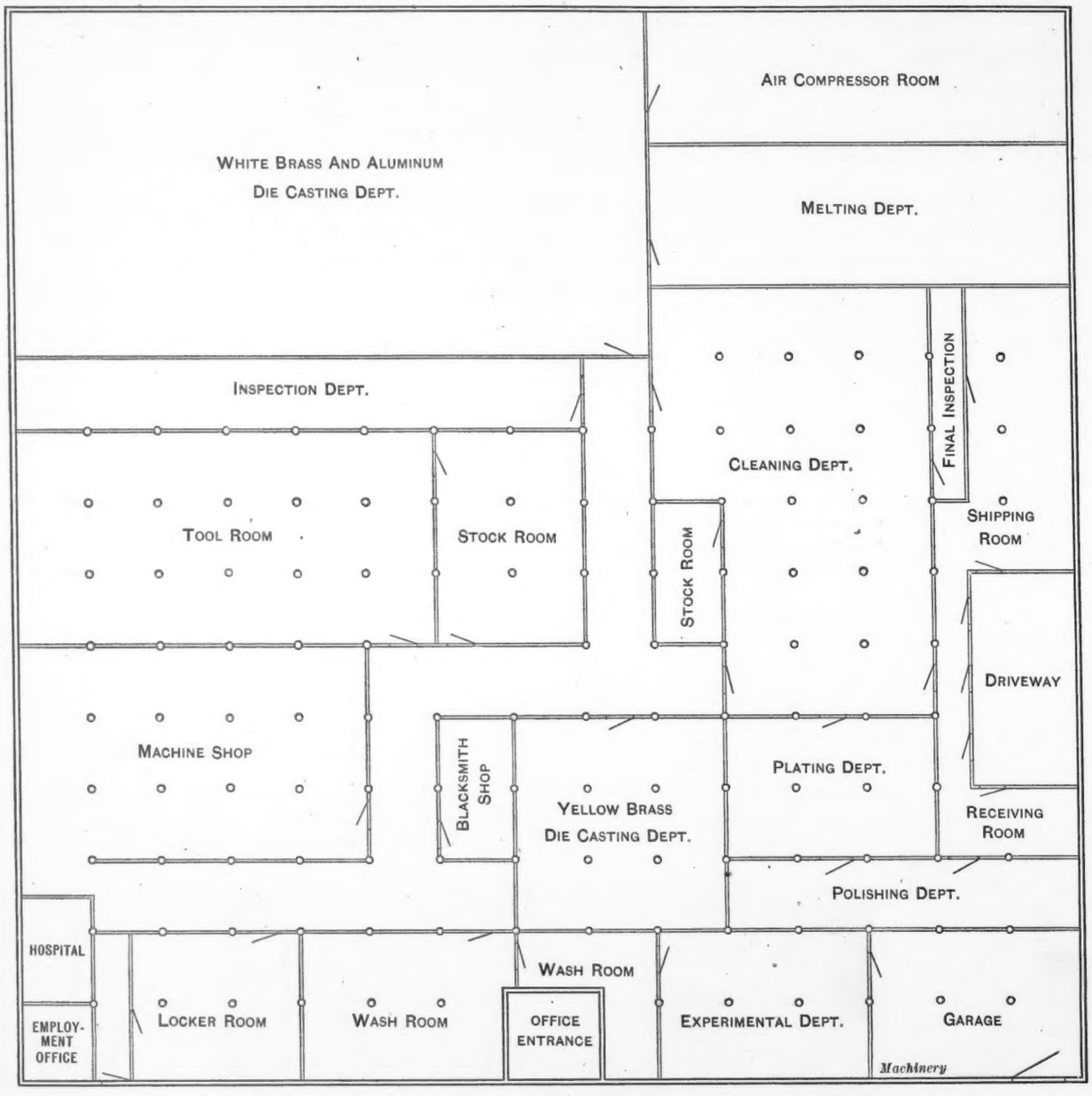


Fig. 2. Plan of the Stewart Mfg. Corporation's Plant showing the Different Departments

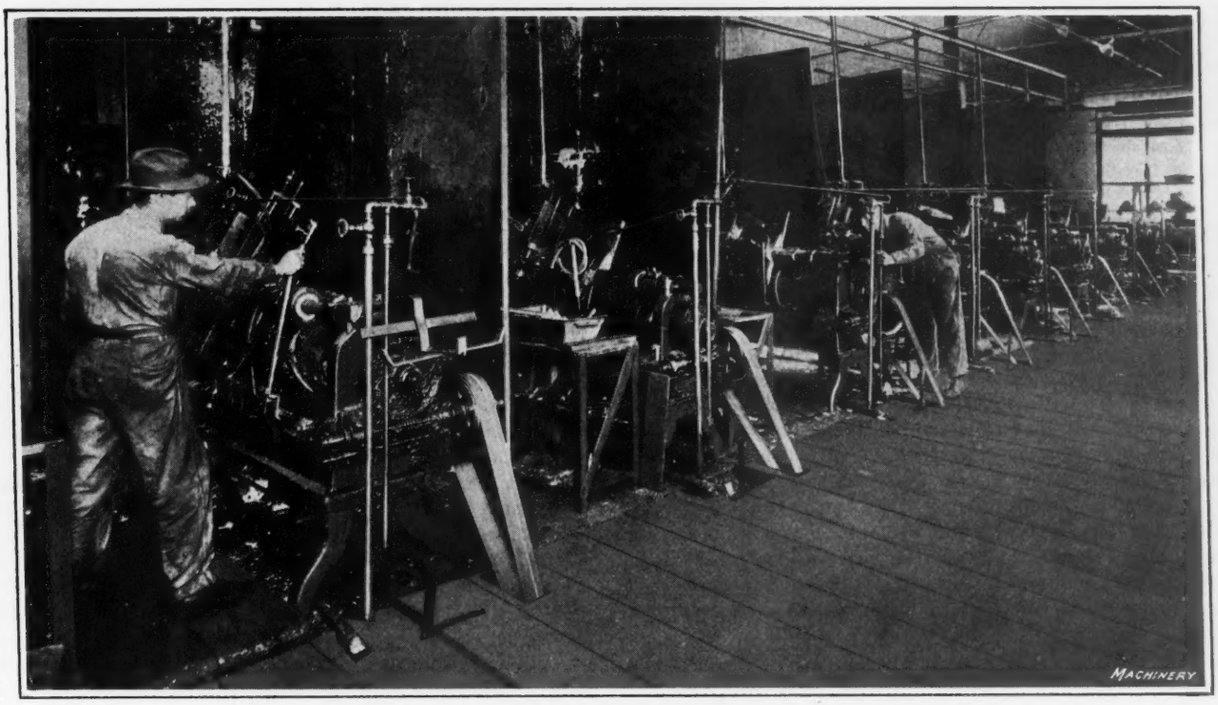


Fig. 3. A View in the Die-casting Department, showing a Battery of Die-casting Machines

ings. These are the machines shown in Fig. 3. They are mechanically operated, being provided with cams for the operation of the various die slides and heads, the action being much the same as that of automatic screw machines. The white-metal machines force the metal into the dies by pneumatic means, while the bearing-metal machines are of the plunger-operated type.

In the past, great difficulties were met with by many die-casting concerns in using machines in which the metal was forced into the dies by compressed air. The Stewart Mfg. Corporation has overcome this difficulty, the secret of success being in the use of dry air. The air is delivered to the machines after having passed through heated coils somewhat in the same manner as steam is passed through coils in a steam superheater. The greatest difficulties with moisture in the air are met with in the hot weather; but the drying system has proved effective even under the most trying weather conditions. All of the standard line of die-casting machines that are referred to are of the horizontal type.

The second type of machines is represented by those used for medium-sized white-metal castings. These are of a special design and the whole machine is mechanically operated. These machines are also of the horizontal type.

The third type of machines used is the vertical type employed for heavy white-metal castings. These machines are mechanically operated and use compressed air for forcing the metal into the dies.

The fourth type of machines employed is the regular line of aluminum-casting machines which are used for aluminum alloys. These machines are of the horizontal type, mechanically operated, except that the metal is forced into the dies

Fig. 4. A View in the Large Tool-room where One Hundred Forty Diemakers and Toolmakers are Normally employed

considerable proportions is required for the making of these machines and for keeping them in repair.

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The die-casting department is divided into sections by sheet-steel partitions, and similar partitions are also placed between the individual machines in each section or battery, as shown in Fig. 3, which gives a good idea of the arrangement of the machines in rows, much the same as would be the arrangement in a regular machine shop. The melting pots are heated by gas, and many of the machines are pneumatically operated, which accounts for the great amount of piping seen in the illustration. The die-casting room is equipped with one hundred twenty-five die-casting machines of different types, according to the work for which they are intended. Altogether, there are five specific types employed.

First, there is the standard line of Stewart die-casting machines employed for white-metal and bearing-metal cast-

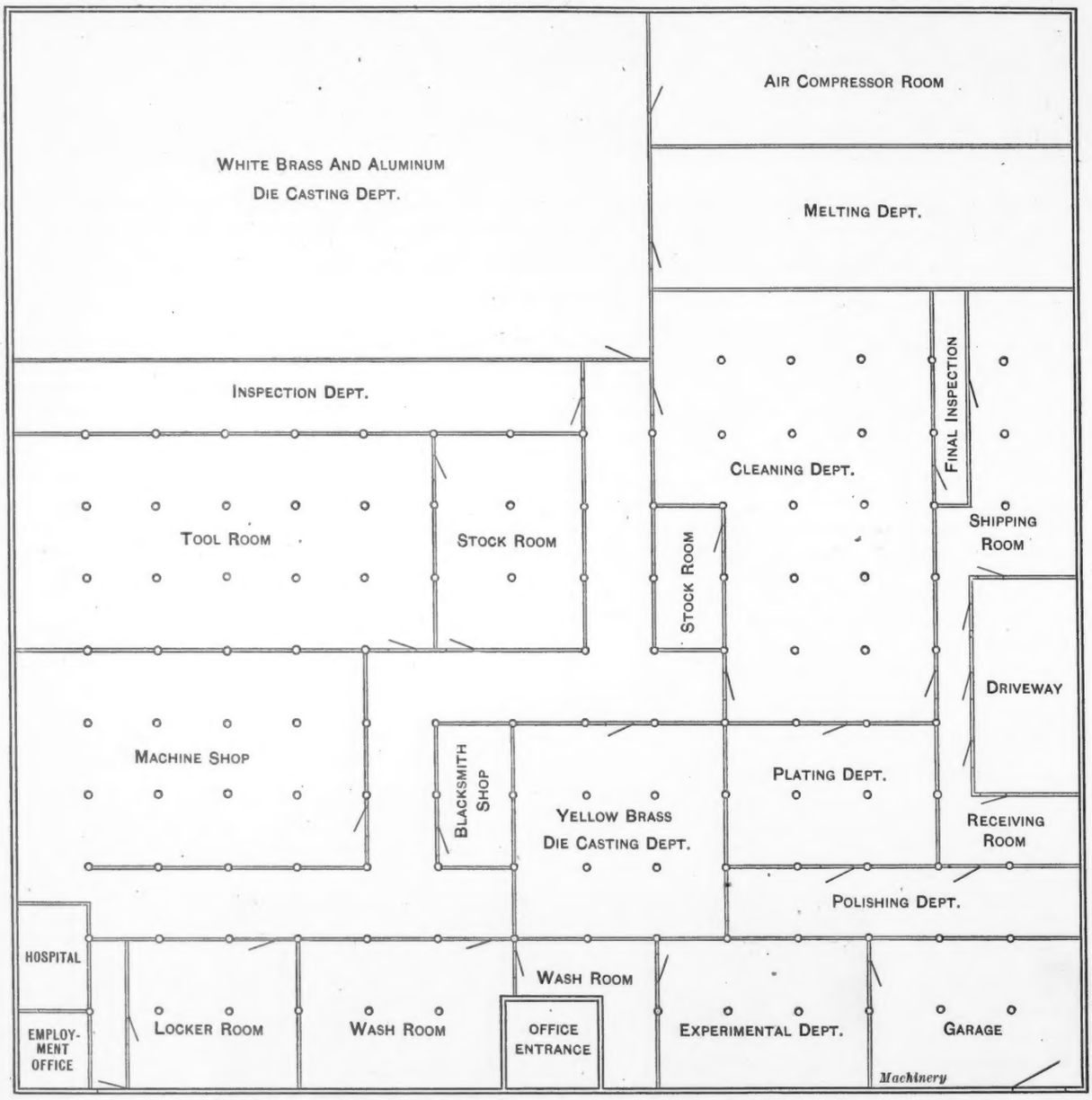

Fig. 2. Plan of the Stewart Mfg. Corporation's Plant showing the Different Departments

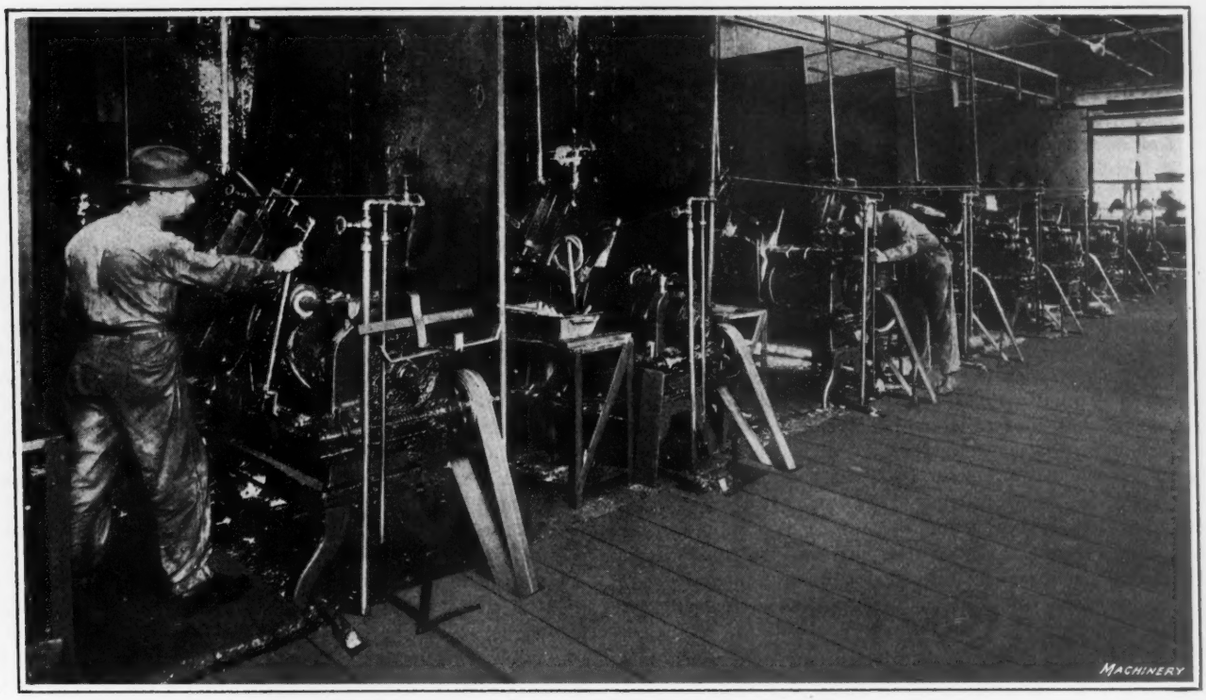

Fig. 3. A View in the Die-casting Department, showing a Battery of Die-casting Machines

ings. These are the machines shown in Fig. 3. They are mechanically operated, being provided with cams for the operation of the various die slides and heads, the action being much the same as that of automatic screw machines. The white-metal machines force the metal into the dies by pneumatic means, while the bearing-metal machines are of the plunger-operated type.

In the past, great difficulties were met with by many die-casting concerns in using machines in which the metal was forced into the dies by compressed air. The Stewart Mfg. Corporation has overcome this difficulty, the secret of success being in the use of dry air. The air is delivered to the machines after having passed through heated coils somewhat in the same manner as steam is passed through coils in a steam superheater. The greatest difficulties with moisture in the air are met with in the hot weather; but the drying system has proved effective even under the most trying weather conditions. All of the standard line of die-casting machines that are referred to are of the horizontal type.

The second type of machines is represented by those used for medium-sized white-metal castings. These are of a special design and the whole machine is mechanically operated. These machines are also of the horizontal type.

The third type of machines used is the vertical type employed for heavy white-metal castings. These machines are mechanically operated and use compressed air for forcing the metal into the dies.

The fourth type of machines employed is the regular line of aluminum-casting machines which are used for aluminum alloys. These machines are of the horizontal type, mechanically operated, except that the metal is forced into the dies

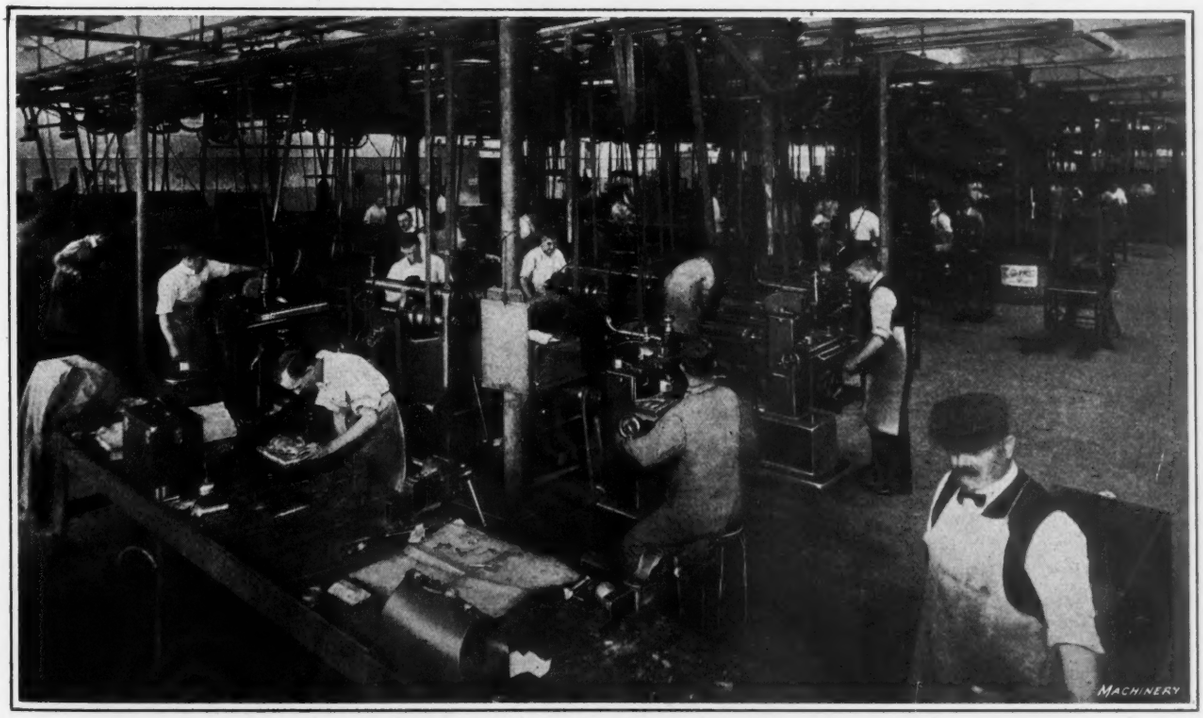

Fig. 4. A View in the Large Tool-room where One Hundred Forty Diemakers and Toolmakers are Normally employed

by pneumatic means. There are some very large machines of this type, however, which are vertical and are pneumatically operated throughout.

Finally, there are the machines used for brass and bronze castings. These machines employ non-metallic molds, are vertical in their design, and are operated entirely by compressed air.

Air Pressures Required to Force Metal into Molds

The pressure for forcing the metal into the molds ranges from 100 to 1500 pounds per square inch, according to the kind of metal being cast and the size and shape of the casting. The more intricate the shape of the casting being made, the higher must be the pressure, so that all the parts of the mold may be properly filled. The size and section thus determines entirely the pressure required. The lowest pressure is used on heavy large castings. On ordinary white-metal and aluminum castings this pressure varies from 100 to 500 pounds per square inch, with 300 pounds per square inch as an average for small castings. Bearing castings are made with high pressures in order to obtain a firm solid casting. The pressure used when casting bearings may vary from 500 to 1500 pounds per square inch. Brass and bronze are cast under comparatively low pressures, not generally exceeding 80 pounds per square inch.

Inspection and Cleaning after Casting

After the castings pass from the die-casting room they are first given a general inspection. This inspection is intended to remove all castings that have obvious defects, such as blow-holes, cracks, defective outside appearance, etc. Such defective outside appearance may be caused by the operator failing to throw out the castings that are made immediately after the dies have been lubricated. The dies must be lubricated at intervals, and the castings that are made immediately after the lubrication are defective and are not intended to be passed along with the perfect castings. An analysis of the metal in the castings is also made at the time of the first inspection, and is repeated from time to time for each lot of castings to insure that the castings retain their proper chemical composition.

From the inspection department, the castings are delivered to the cleaning room. In case large quantities of similar castings are made, special tools are generally provided for cleaning and trimming the castings. The equipment in the cleaning room consists of punches, arbor presses, hand screw machines, lathes, drill presses, and milling machines. Oil-groove machines are also provided for cutting oil-grooves in bearings, or for cleaning out oil-grooves that have been cast directly in the bearings.

From the cleaning room, the castings are sent directly to the final inspection department, where they are inspected mainly for the operations in the cleaning room and are also gaged to make sure that the dimensions are correct. From this department the parts that are not plated go to the shipping room. If the parts are to be plated, they pass from the inspection room to the plating room, and after plating, they are polished and are then inspected again. Nearly all of the plating performed on die-castings is nickel-plating, although some parts are also brass-plated.

Tool-room and Production Department

The Stewart Mfg. Corporation employs about six hundred men. An idea of the importance of the toolmaking department in a die-casting plant may be formed from the fact that out of this number nearly 25 per cent, or 140, are toolmakers engaged in the making of dies for the product made by the company. When the dies are made, samples are cast from them and these samples are checked by the tool inspection department. In some instances, the samples are sent to the customers for approval. When returned from the customer with his approval, the office notifies the production department that the samples meet the requirements, and the production department then schedules the work for the die-casting room. The general foreman of the die-casting room determines the machine on which each particular job is to be done, unless a special device is required for a special die-casting job, in which case this equipment would be provided by the engineering department. The production department also is required to see that proper gages, cleaning-up tools, trimming dies, etc., are provided for each job.

The complete organization required for a plant of the size described includes about 200 men in the melting and casting rooms, 120 men in the cleaning department, 50 men in the inspection department, and 40 men in the polishing and plating departments. It has already been mentioned that the toolmaking department employs about 140 toolmakers, and the machine shop, in which the company's own machines are being built, employs about 50 men. As many as 800,000 die-castings have been made in a single day, indicating the enormous production that is possible by die-casting methods.

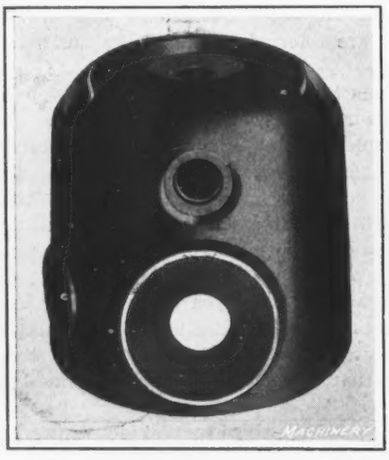

Fig. 5. Small Motor Housing produced by the Die-casting Process

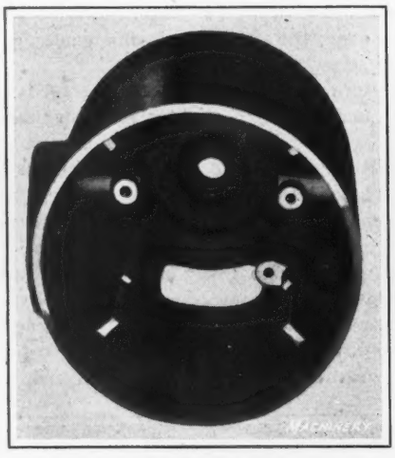

Fig. 6. Another View of the Housing illustrated in Fig. 5

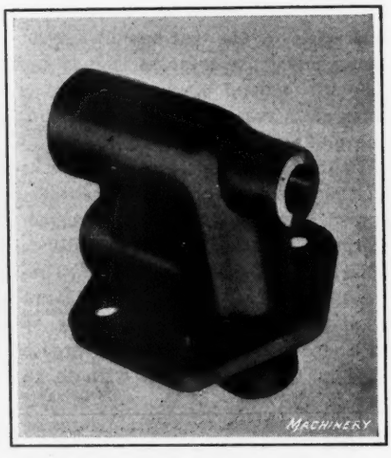

Fig. 7. A Bracket with Bores and Holes, produced completely in Die-molds

Present Possibilities in Die-casting

The advantages gained by the use of die-castings have frequently been pointed out, and the accuracy obtainable and saving in machine work are well known. Die-castings, when they come from the mold, are practically finished parts, except for the removal of fins and some trimming or shaving that may be required on some surfaces. Holes can be cored accurately within 0.001 inch, and the most accurate bearings require no other machining work than a finish-reaming operation. The art has now advanced so that quite large castings are being made by this process, and shapes formerly believed too intricate to be handled in this way are now successfully dealt with. Figs. 5 to 10, inclusive, show a

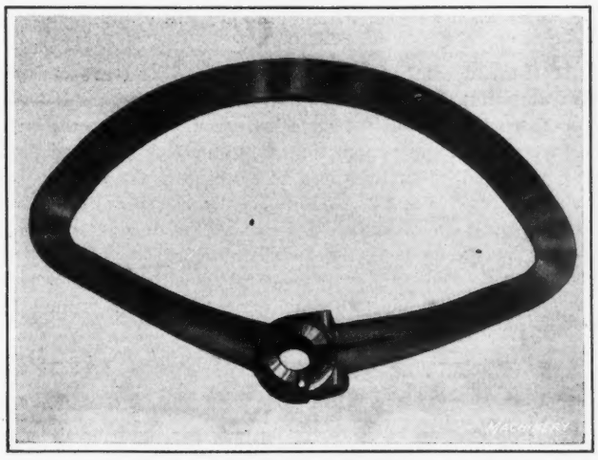

Fig. 8. A Slender Piece of Large Dimensions, which well illustrates the Possibilities of Die-casting

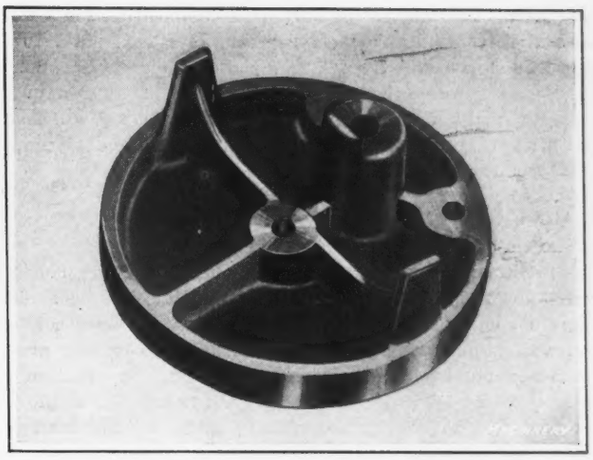

Fig. 9. Another Example of a Die-cast Product, showing the Application to Parts with Numerous Holes and Projections

number of castings made from white-metal and aluminum alloys, while Fig. 11 shows castings made from brass. The casting of brass parts, especially parts such as those shown in Fig. 11, by means of the die-molding process is a comparatively new development. Non-metallic molds of special composition are used for this purpose; otherwise the process is, in principle, similar to the method used for casting white-metal and aluminum alloys.

Figs. 5 and 6 show outside and inside views of a small motor housing, indicating how all the holes and bores are provided directly in the die-casting, and giving a fair idea of the complicated shapes that may be produced in this manner. The bracket in Fig. 7 is another good example of work of this character, while Fig. 8 shows a casting of an entirely different kind and indicates what can be done along the lines of producing a part of slender proportions but of large dimensions. Fig. 10 shows examples of gears cast with the teeth in place. These teeth will not require machining, but will run satisfactorily as they come from the die-molds. Of course, gears are only die-cast when they are not subject to a great deal of wear, and when the strength of the teeth need not be as great as if the gear were made from steel.

It should be noted, however, that at the present time die-castings are used in many instances where considerable strength is required. A few years ago it was not thought possible to use parts made in this manner for any conditions where strength was an important factor. Special treatment of the die-cast metal and special compositions of alloys have been developed which have a considerable tensile and compressive strength. Aluminum alloys, especially, are made that give very satisfactory results as regards strength and durability. The field for die-castings is, therefore, constantly widening, and as the art of making die-molded castings from brass and bronze is being further perfected, there will be a still broader scope for this industry.

Metals Used for Die-castings

In the early development of the die-casting art, a great many alloys were experimented with and the variety of alloys used at that time was very great. With the development of the industry, however, it has been found that a relatively small number of alloys meet the requirements, and the different compositions employed have narrowed down to a few comparatively well standardized metals. Broadly speaking, the metals that are die-cast may be divided into four broad groups as follows: (1) the white-metal group; (2) the tin-base group; (3) the aluminum group; and (4) the brass and bronze group. In addition, lead-base alloys are becoming quite generally used for bearing purposes.

The White-metal Alloys

The white-metal group comprises the zinc-base alloys which frequently are also known as "white brasses." The metals in this group used for die-casting purposes contain zinc, tin, and copper. The zinc-base alloys are more easily handled in the die-casting process than any other alloys and are, therefore, most generally used. They may be employed for all purposes where cast iron or yellow brasses can be used. It should be noted, however, that the tensile strength of the alloy is less than that of the brasses, so that castings made from this alloy can only be used to replace yellow-brass castings when the tensile strength required does not exceed from 17,000 to 20,000 pounds per square inch. This strength, however, is obtainable by zinc-base alloys when the metal is properly treated during the process of alloying or casting. Zinc-base castings present about the same wearing surface as cast iron or yellow brass and are used extensively for small electric motor frames, magneto castings, many automobile parts, and castings used in the electrical industries. Generally speaking, the characteristics of the zinc-base alloys used for die-castings are similar to those of

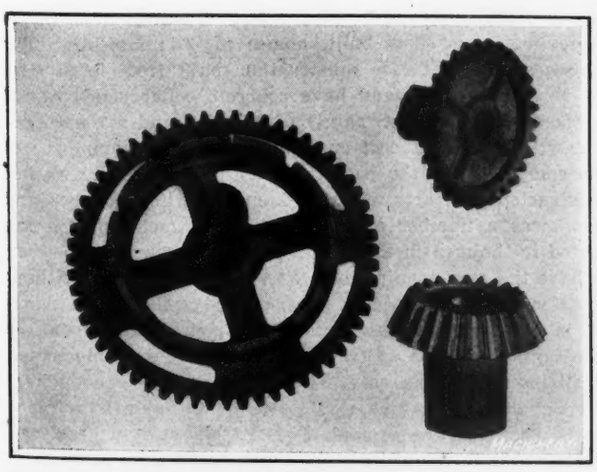

Fig. 10. Die-cast Spur and Bevel Gears

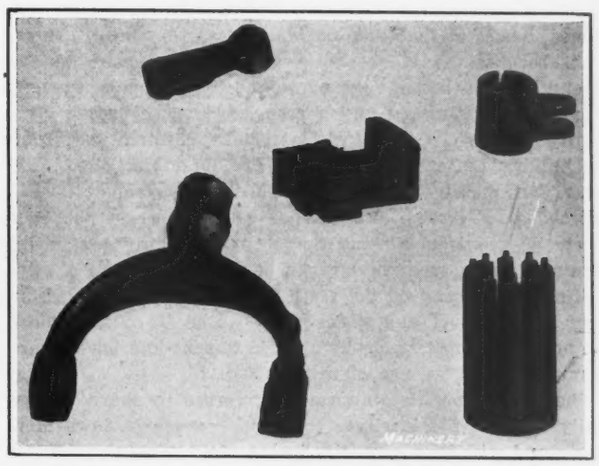

Fig. 11. Die-molded Brass Castings

cast iron. The most commonly used composition for a zinc-base alloy contains about 86 per cent of zinc, from 7 to 10 per cent of tin, and from 4 to 7 per cent of copper. Sometimes there would be some slight trace of aluminum or bismuth in the metal. A higher percentage of tin will make the alloy very ductile, while a higher percentage of copper will produce greater hardness.

The Tin-base Alloys

The tin-base alloys are used principally for bearings, and are, practically speaking, nothing but babbitt metals, it being well known that the so-called babbitt metals vary considerably in composition, some containing up to 90 per cent of tin, while the cheaper bearing metals in the babbitt group contain a much smaller percentage of tin. In addition to being used for bearings, the tin-base alloys are also employed for parts that must be resistant to acids, as, for example, parts for milking machines and other apparatus used in the food industries. The most acid-proof of the tin-base alloys are those which are high in tin, a favored composition being 90 per cent of tin, 4 per cent of copper, and 6 per cent of antimony, the copper and antimony increasing the hardness of the alloy.

Aluminum and Aluminum Alloys

Pure aluminum can now be die-cast on a commercial scale, but this is very seldom done, because there is no particular commercial application for such castings. They are too soft for commercial use, and the standard aluminum alloys which contain a high percentage of aluminum alloyed with copper are so far superior in every respect to the pure aluminum that these alloys are practically always used when a light casting is required, having considerable strength. The most commonly used of all aluminum alloys is that known as No. 12 composition, which consists of 92 per cent of aluminum and 8 per cent of copper. This alloy, when produced by die-casting, will have a tensile strength of 20,000 pounds per square inch, and is employed whenever a light strong alloy is required. The die-casting process increases the tensile strength of this alloy about 25 per cent.

Another alloy that is quite frequently used for automobile parts is a magnesium-aluminum alloy containing from 2 to 5 per cent of magnesium and from 3 to 7 per cent of copper, with the remainder aluminum. This alloy is much stronger than the No. 12 alloy, and by proper treatment in melting and casting, it is possible to obtain a tensile strength of from 32,000 to 35,000 pounds per square inch. The copper hardens the metal while the magnesium seems to act as a deoxidizer and produces a closer grain in the casting than can be obtained in an alloy consisting simply of aluminum and copper. Nickel is sometimes added to this alloy in quantities of from 1 to 3 per cent. The effect of the nickel is to produce still greater hardness than is obtained by copper alone, and in addition, the casting will have a much brighter finish.

When gears are die-cast, the No. 12 alloy is generally used, as it produces a good wearing surface. It should be mentioned, however, that it is not very often that gears are die-cast, because, as a rule, the gear teeth require greater strength and a better wearing surface than can be expected from a die-casting, in which case, steel is, of course, practically the only satisfactory material. Nevertheless, there are hundreds of cases where gears are not subjected to heavy wear, but merely transmit motion without transmitting a great deal of power, and in that case a die-cast gear will meet the requirements, as the accuracy required is easily obtained, and a great saving can be effected because of eliminating the cutting of the teeth on a gear-cutting machine. Spur, spiral, bevel, and worm gears can be die-cast, although the process is most generally applied to spur and bevel gears, examples of which are shown in Fig. 10.

The magnesium-aluminum alloy referred to above is especially suitable for intricate castings, because it flows more freely and will fill all cavities in the mold perfectly.

Comparison between Aluminum-alloy and White-metal Castings

White-metal castings are easier to make and are cheaper than aluminum-alloy castings and are, therefore, used whenever there is no need for an alloy stronger or lighter than the zinc-base composition. Aluminum-alloy castings, however, are used when lightness and strength are required at the same time. The alloy itself is more costly and does not cast as easily, making the die-casting produced from this alloy more expensive. The aluminum castings, however, have a fine finish and only need to be polished after they come from the molds, whereas white-metal parts must be plated if a high polish is required.

Brasses and Bronzes

Any composition of brass or bronze can now be die-cast by methods that have been developed successfully during the last year or two. Castings of complicated shape can be produced, as indicated by the examples shown in Fig. 11, particular attention being called to the cage shown in the lower right-hand corner of the illustration. Practically the same shapes can be produced in brass as are produced from the other die-casting alloys, the only limitation being that very small holes cannot be cored and produced directly in the casting, but must usually be drilled afterward. The reason for this is that the pins of small diameter which are necessary to produce these small holes show a tendency to warp when subjected to the high temperatures which are required for keeping brass and bronze in a molten condition. The advantage of die-cast brass and bronze pieces over those cast in sand is that the surface of the casting is harder than a sand casting would be, while the interior of the casting is practically the same as that of a sand casting.

The preceding review gives a general idea of the present state of the die-casting art. There is, however, a constant development taking place in this industry, and work formerly thought impracticable for production by die-casting methods is successfully undertaken. It is likely that the next few years will show a still further advance of the art, especially in the casting of the metals melting at high temperatures, such as brasses and bronzes. When the art of casting brasses and bronzes in permanent molds, such as are used in the die-casting process, has been fully developed, it will revolutionize many of the processes now used in the metal-working field.

* * *

WESTINGHOUSE COMPANY BUILDS HOMES FOR EMPLOYES

Owing to the difficulties experienced by the employes of the Westinghouse Electric & Mfg. Co. in obtaining homes near the East Pittsburg works, the company has resumed its home building activities that were postponed during the war. Forty-eight houses are now under construction and it is expected ultimately to erect, on the tract of 109 acres on which these homes are now built, homes for 600 families. The houses are of first-class construction, built from brick with hollow tile backing, and have concrete cellars and cement porches. They consist mainly of five, six, and seven rooms, and will be sold at cost on easy terms to the employes of the company. In the past the Westinghouse company has constructed a great number of homes for its employes and also owns a number of homes and apartments which are rented to the men in the plant. An effort is made, however, to have the men acquire their own homes, and this, without question, is one of the best steps toward assisting the workers in becoming stable, self-respecting men and home-owners who cannot be easily swayed by unsound economic doctrines. If all manufacturing enterprises of a size large enough to warrant the undertaking would attempt to "plant" their employes firmly on the ground, they would render a great service both to their men and to the industries as a whole.

Cylinder Patterns

By Joseph A. Shelly

Second of Two Articles Describing Methods of Laying Out and Constructing Patterns and Core-boxes for Pump Cylinders

THE first installment of this article on cylinder patterns dealt with steam-port core-boxes, exhaust-port core-boxes, pump cylinders, and pump cylinder core-boxes. The present and last installment of the article will deal with cylinder patterns for vacuum pumps, core-boxes for jacketed cylinders, cylinder head patterns, cylinder feet, and discharge cover patterns.

Cylinder Patterns for Vacuum Pumps

The vacuum pump cylinder pattern shown in Fig. 11 has a valve plate located at an angle. The pattern is boxed with cross-bracing where needed and is well corner-blocked inside. It is made to mold with the flange down, the molder's parting running along the bottom of the flange. The print only is made in the drag, and the portion from this parting to the center of the barrel is in the cheek and the rest of the pattern in the cope. The hub on the end at the flange, the feet on the barrel, and the half flanges with core-prints under the pattern parting are loose. The two half flanges are let into the ends of the pattern and dovetailed into place. These half flanges and core-prints are turned, but the barrel itself is planed and the swells at the ends built on.

An end view of the core-box is shown at *B*. This view shows how it was built and also the angular valve plate which holds the discharge valves. A central rib in the upper half divides the core, making three cores in one box. The upper and lower halves of the box are loose from the valve plate, being held in position by dowels. These cores could be made in separate boxes, but this type of cylinder is very light and great trouble was experienced when the cores were made that way. This difficulty led to the adoption of the box illustrated. To avoid getting the core in the wrong way, a corner of the print was cut away and the box filled in to suit; the piece cut away was small and the box was filled in right down to the plate which left a V-shaped corner in the casting but did no harm. Valve-seat prints were located on the plate and on the level part; they were placed on both sides so that the seat cores would project into both larger cores and keep the top ones from slipping down the incline. The prints on the angular part of the plate had to be tapered enough to draw when the plate was lifted in the direction indicated by the arrow at *C*. The top of the box was strickled to fit the swells on the bore core.

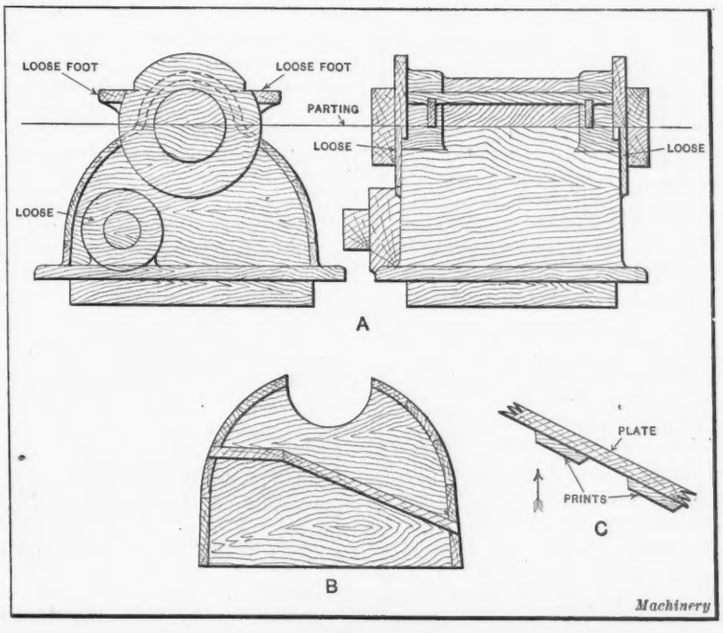

Fig. 11. Pattern for Cylinder of Vacuum Pump

Core-box for Jacketed Cylinders

Jacketed cylinders are those having a space between the outer and the inner walls for circulating cooling water. The core used for making this space is called a jacket core and must fit around the bore core. It is supported by openings either through the sides of the cylinder or through the flanges at the end. When the openings are through the sides, they generally have bosses so as to give enough metal to tap for pipe plugs to close the openings, as at *A*, Fig. 12. The core-box *B* is a half round box corresponding to the outer diameter of the jacket and filled in at each end to the inner diameter for the strickle to slide on. The cavity in the bottom is to reduce the amount of metal in the breast, and there are blocks in this cavity to form metal around the straight ports that extend through the breast face. The jacket core-box must always be filled in where openings extend from the outside to the inner bore to form metal around such openings. The cavity of this box was filled in to make the other half of the jacket core. With most jacketed cylinders it will be found more convenient to build projections on the side instead of at the bottom. These boxes are sometimes built the reverse way, and the openings then have to be cut through pieces doweled to the ends and running lengthwise of the box, but a core made in this way is difficult to handle. When the openings are to extend through the ends a print corresponding to the outside diameter of the jacket is made on the end of the pattern, as at *A*, Fig. 13. The openings are cut through the end piece that is placed in the core-box as at *B*, the piece parting as shown. The inside diameter of these ends must be the same as the diameter of the bore core around which the end fits; therefore, in order to make the part between the ends right for the inner diameter of the jacket, a strickle must be used to remove the surplus sand as at *C*. Small jacket boxes are often made complete, and this type of cylinder is frequently poured with the mold on end to secure a sounder casting.

A back cylinder head is shown at *A*, Fig. 14.

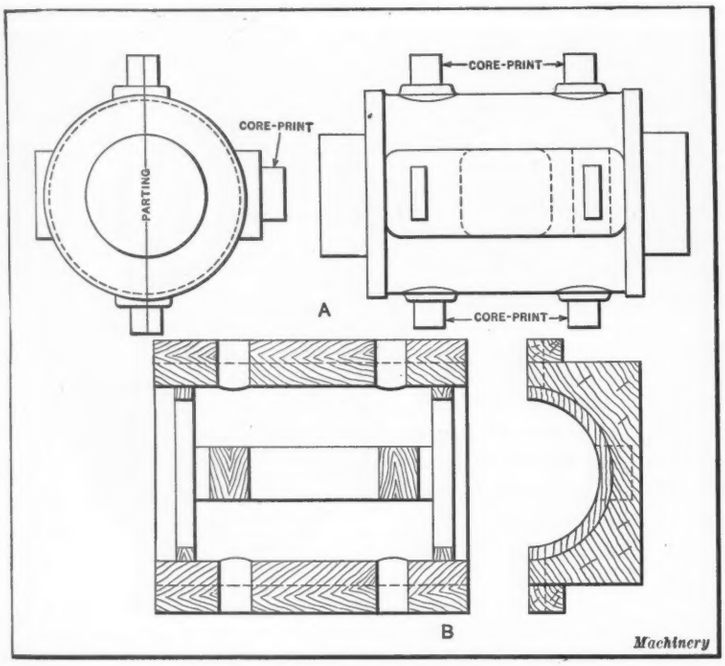

Fig. 12. Pattern and Core-box Work on Jacketed Cylinder

The swell on the outside is necessary because of the recess turned on the inner side to accommodate the piston-rod nut. The smaller sizes are usually made of a solid piece, preferably of hard wood, but the larger sizes must be constructed by segments with the rim in three courses and the center of a solid piece as at *B*. Other examples of segment construction are shown in Fig. 15. In fitting the segment ring and center together, the recess is first turned in the ring and the center turned to fit it; the ring is then fastened in place and the inside turned to a templet. The pattern is

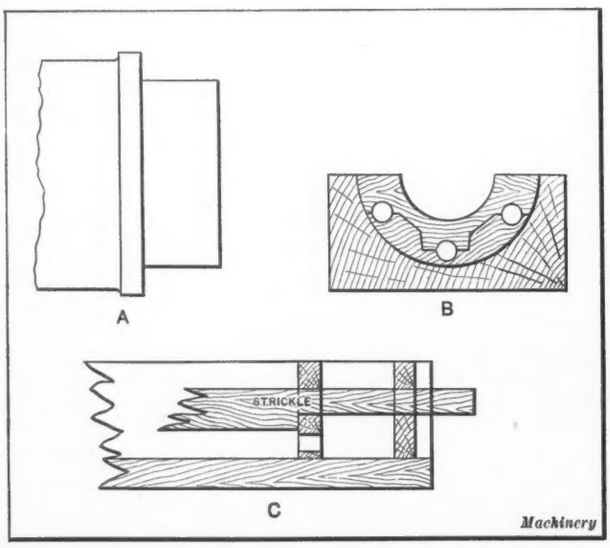

Fig. 13. Details of Pattern and Core-box Work on Jacketed Cylinder

next rechucked on the fitting piece for turning the outer face; the finishing of the diameter should be left to the last. A front head *B*, Fig. 15, is built in the same way except that instead of a swell it has a hub to form the stuffing-box. If it is the type of head that has a deep projection into the cylinder, which will come into the cope, it should be made loose, and if the loose piece is doweled to the cope side there will be no necessity for rechucking the pattern. Water-jacketed heads are made in a similar manner to cored pistons, one pattern usually being made to answer for both front and back heads by placing a hub in the core-box and a boss on the outside for the purpose of making the stuffing-box.

Cylinder Feet

Cylinder feet are either cast as a part of the cylinder or are separate pieces bolted to pads placed on the cylinder for that purpose. Duplex steam cylinders are often cast separately and bolted to a long foot called, in some localities, a "cricket." Small feet are usually what are known as open and have a single central rib or two ribs placed at the edges. These feet are fastened to the cylinder by gaining the web (which is made long) flush with the joint and fastening with screws as at *A*, Fig. 16. The closed or cored foot *B* has a projecting core-print. This core-print must be long enough to balance the core that is made in a half box which does not part, as it is possible in a case like this to give the box considerable taper. The rounded end is formed by a loose piece fitting into the end of the box. In making these feet the sides *a* (see view *C*) should be thick enough to cut them back to make the core-prints, and the top piece *b* should be kept back so that the flange may be fastened to the sides and also be nailed through the face into *b*, as this does away with the necessity of fitting and fastening to a taper. The top part of the print is put on last and the inside corners should be reinforced with corner-blocks. This style of foot is fastened

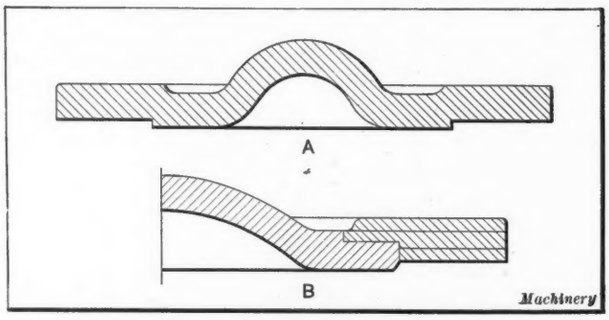

Fig. 14. Cylinder Head Patterns

from the inside, which is an easy matter when it is staved; otherwise screw pockets will have to be made in the joint and the screws driven at an angle.

When the face of the foot is parallel to the parting (as at *D*, Fig. 16) there is no necessity of parting it and if the lift on the inside is not deep and of such form that it provides plenty of taper, it may be made to leave its own core. If the lift is deep and heavy, a print should be placed on the face and a core-box made. This print need not be very deep as its only function is to locate the core which in most cases will have to be hung in the cope.

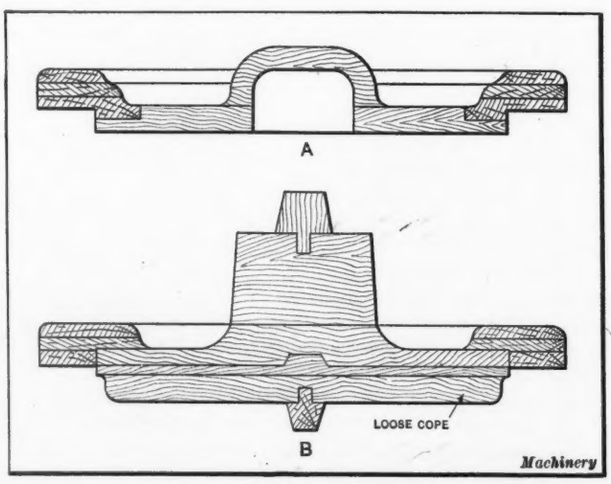

Fig. 15. Other Examples of Cylinder Head Patterns

There are a number of styles of separate feet to bolt on, the designs *E*, *F*, and *G* being typical. Pattern *E* is solid, the sides being nailed to the end pieces which are worked to shape and fastened to the top before the sides are nailed and glued. Pattern *F* has a central web and is parted and usually made in two ways; at view *F* the sides are placed between the top and bottom and the half web is fastened on each joint, while at *G* the top and bottom are placed between the sides which run to the center, and the joint is rabbeted to receive the web. The construction at *G* does away with the projecting end wood, which is a good feature and also eliminates the feather edge where the side joins the bottom at *F*.

The draws on some of these patterns are quite deep so plenty of draft should be provided on the inside. Loose feet are rabbeted into the barrel in order to avoid fitting to the round.

The style of machine foot shown at *H*, Fig. 16, is closed on the bottom and is only partly open at the top; it is necessary to make this foot with a core to obtain the best results. The core-print is made flush with the under side of the top pads. The core-box extends from the end of the foot to the center rib and the round column is fastened to a batten that is screwed across the face of the core-box.

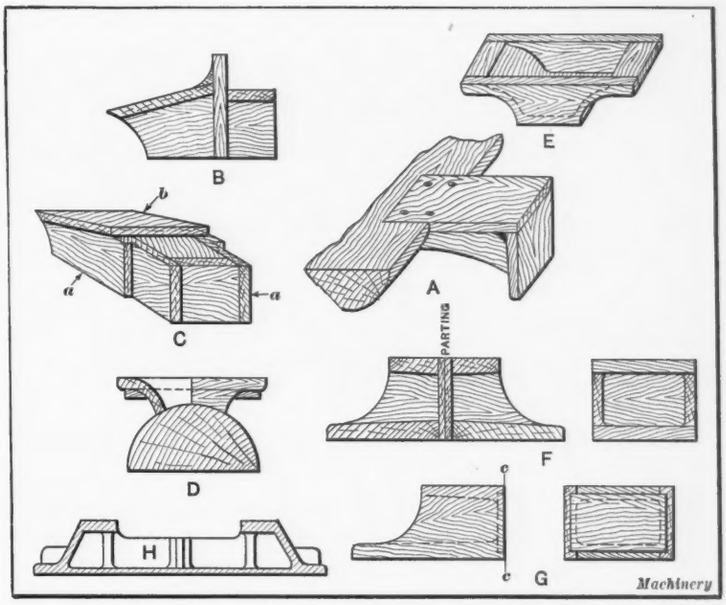

Fig. 16. Different Forms of Feet or Supports for Cylinders

Patterns for Discharge Covers

Patterns for small discharge covers (*A*, Fig. 17) are frequently carved from a solid piece. Hard wood is best for the purpose. The pattern block is parted through the center for laying out, the inside finished, and the block glued together before the outside is touched.

A larger size of cover such as is illustrated at *A*, Fig. 18, will have to be built up. The lower rounded corner should be worked inside and out up to the point where it meets the curved top; this point is indicated on the lay-out at *a*. This curved part is made like molding and is mitered at the corners as shown at *B*. These miters are cut in a miter-box with a form to hold the molding in place. Half-lapped joints are used at the corners where the flange is fitted around the mitered part and the top is made of two pieces of suitable thickness fitted into the opening in the mitered frame and resting on the angular edges. The reason for fitting this piece in halves is to lay it out on the joint and bandsaw the central hole. The hand-hole bosses are fitted afterward, and the core-prints are left loose for drawing. If the opening in the mitered frame is too large to be filled by a piece made in this way, it will have to be built of comparatively narrow pieces.

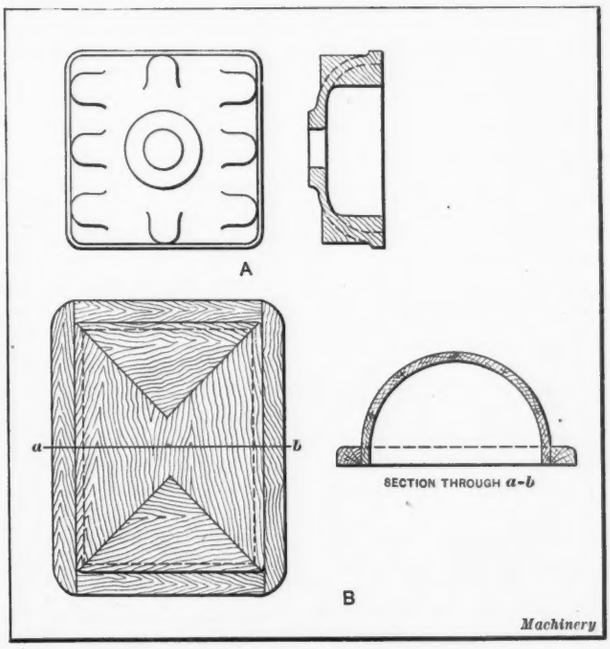

Fig. 17. Cover Patterns

Covers are sometimes semicircular in cross-section as at *B*, Fig. 17, in which case it is customary to build a piece the full section lengthwise and miter the ends. This piece is built on forms with feathers in the joints and it is mitered on the band saw by fastening a board to the bottom on which the miter is laid out. By cutting the miter on the straight part with a band saw the band saw can be kept to the line by watching through the arch. The ends are cut in the same manner, a form being used to hold them in the correct position.

The discharge cover shown in Fig. 19 which has an opening at each end at the top and hand-hole pads on the sides, presents a more difficult molding problem than the other covers, although the pattern itself is perhaps not so difficult to make as the one with the arched top. The pattern is made to leave its own core and to mold while in the position shown in the illustration. It must be given a fair amount of draft on the straight sides, tapering from the top side of the flange at the bottom up to the parting at the top. The hand-hole plates, with prints attached, are doweled to the angular ends with the dowel-pin holes bored parallel to the line of the draw. The pipe at the top is turned and cut to make the loose ends below the parting. These short pieces have hard wood pieces fastened on the ends to make the fillet which is left ¼ inch thick at the edges and gained into the sides and held in place with dovetails; a single dovetail piece is placed in the center of each. In turning the pipe section, dowel-pins should be placed in the core-prints, and the print to carry the core is made to run through the pattern from side to side on the inside so that a single length of straight

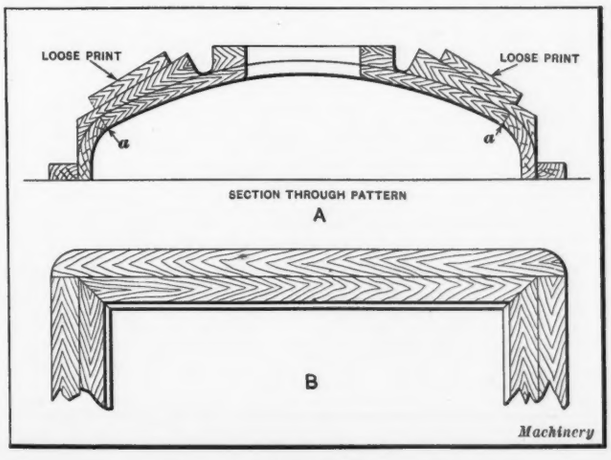

Fig. 18. Pattern for Large Cover

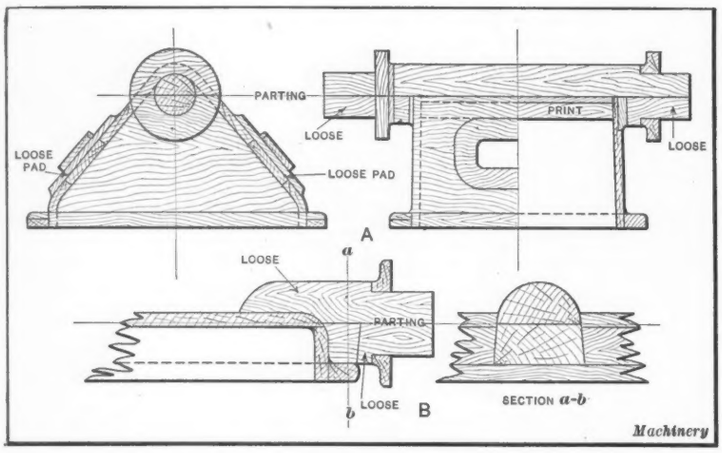

Fig. 19. Discharge Cover Pattern made to leave its own Core

round core is all that is required. In making these patterns, the body is made to fit the inside of the flange which is glued after being framed with corner lap joints, as this makes a pattern that cannot spread and can be more securely fastened than if the pattern is built on top of the flange which sometimes results in the flange projecting inside of the pattern and causing an under-cut.

The vacuum cylinder cover shown at *B*, Fig. 19, is a flat shallow box with the discharge opening on the top and projecting over the side. The parting line is indicated on the illustration. The piece below the parting is made loose at the flange. This parting in the mold does not follow the pattern parting but runs along the center and extends at an angle to the corner of the flange. In order that the section over the flange may lift away with the cope, it is made as shown in section. Very often hand-hole pads will project on the flange and cover a spot where a stud hole is to come and it will be necessary to place a core-print on the flange and core a pocket for the nut.

* * *

A RECORD OF BUSINESS CONDITIONS 1905-1919

The accompanying chart provides an interesting record of the ups and downs in the machinery business during the past fourteen years. The chart is based upon the volume of business done by the Bantam Ball Bearing Co., Bantam, Conn., and while it represents particularly the conditions in the ball bearing industry, it has been ascertained that it pictures quite accurately the conditions that have prevailed during the past fourteen years in the machine tool and some of the allied industries as well. Of course the values in the chart must be considered simply as relative, because the Bantam Ball Bearing Co. has probably grown more rapidly during the past fourteen years in proportion to its size in 1905 than have many of the old established concerns. Hence the volume of business in 1906 and 1907 will appear small as compared with the volume of business done in 1913 and 1914; but the interest centers not so much in the direct comparison of different years as in the ups and downs of the business during the period covered by the chart. For example, the effect of the so-called "Roosevelt panic" in the latter part of 1907 is easily discernible and so is also the effect of the "Wall Street panic" in the latter part of 1910.

In 1913 we notice two decided drops, each lasting a couple of months. The first of these drops was caused by the apprehension produced by new tariff legislation and the second by similar apprehension after the new currency and banking legislation had been passed. It will be noticed, however, that business recovered rapidly from the effects of these depressions and showed an upward tendency for several months previous to the beginning of the war in August, 1914. At that time the war panic caused a very decided drop lasting for about six months, after which there was a gradual improvement resulting in a tremendous output immediately after the United States had entered the war in 1917. The signing of the armistice did not immediately affect the output of many industries and this is also evident in the chart, where a high output was carried over into the first two months of 1919. From that point on there was a drop back to the 1916 conditions, after which an improvement is again recorded.

This chart was begun when the Bantam Ball Bearing Co. started in business in 1905. It is open to the inspection not only of the management, the directors and the stockholders, but also of the employes of the company. In addition to showing the fluctuations in actual output of the plant, the chart also contains, in an upper part (not shown), a line indicating the capital and the value of the plant inventory. The freedom with which the employes are permitted to learn of the actual financial conditions and the business fluctuations is stated to be one of the many reasons for harmonious relations between employer and employes at the Bantam Ball Bearing Co. It has always been the belief of the company that the more freely the management permitted the employes to study and become familiar with the actual financial conditions of the business, the less likelihood would there be for misunderstandings.

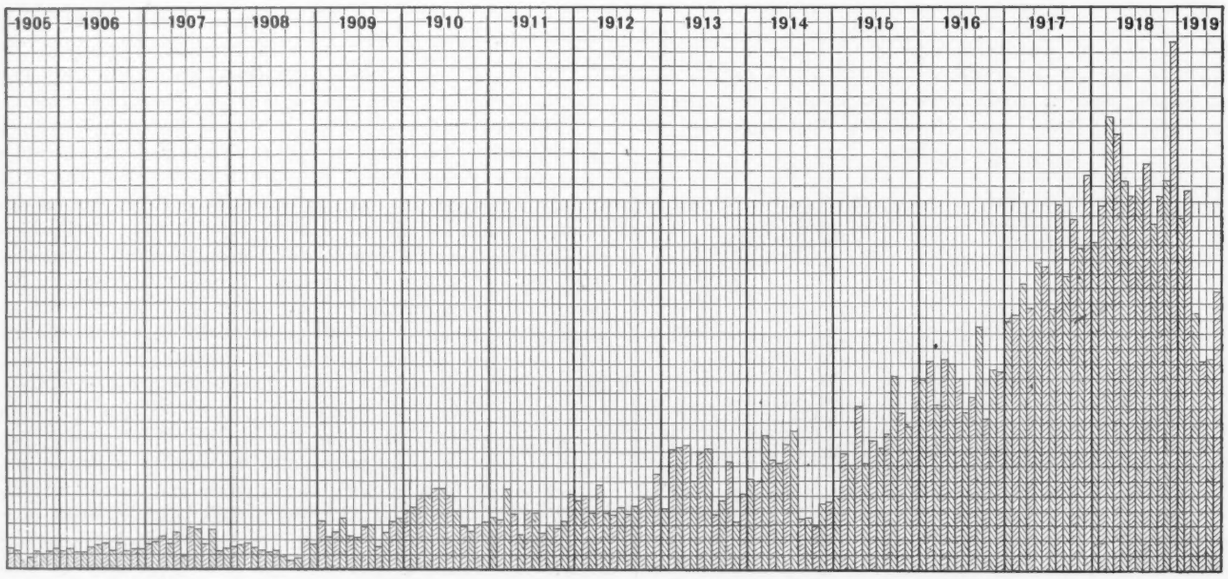

Chart showing Record of Business Conditions in the Machinery Industry from 1905 to 1919

LETTERS ON PRACTICAL SUBJECTS

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FORMING AND DRAWING DIES FOR SHEET-STEEL SHELLS

Difficulties encountered in the drawing operations on a steel shell, which is used as a vacuum pot on a certain type of computing scale, were overcome by using the dies here illustrated. The illustrations show each die used and the drawn shell as it appears after each operation. All the steel parts employed in the forming and drawing operations are hardened and ground. The corresponding parts of the various dies have the same reference letters throughout the description. The blank of sheet steel from which the shell is drawn is 0.065 inch thick and 5 7/16 inches in diameter.

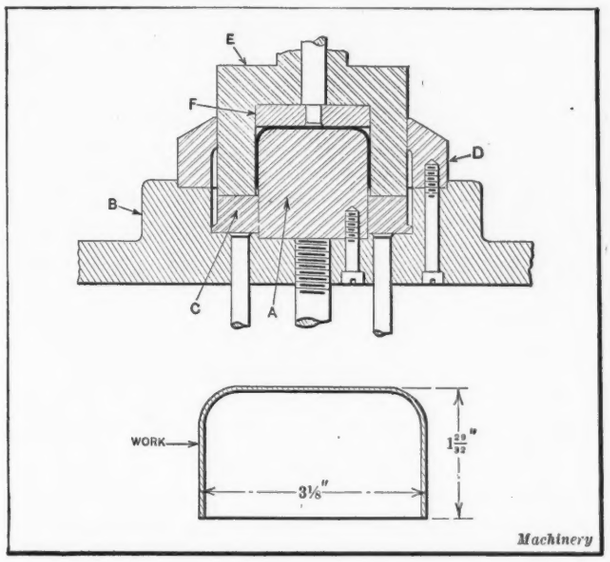


Fig. 1. Blanking and Forming Die used on First Operation

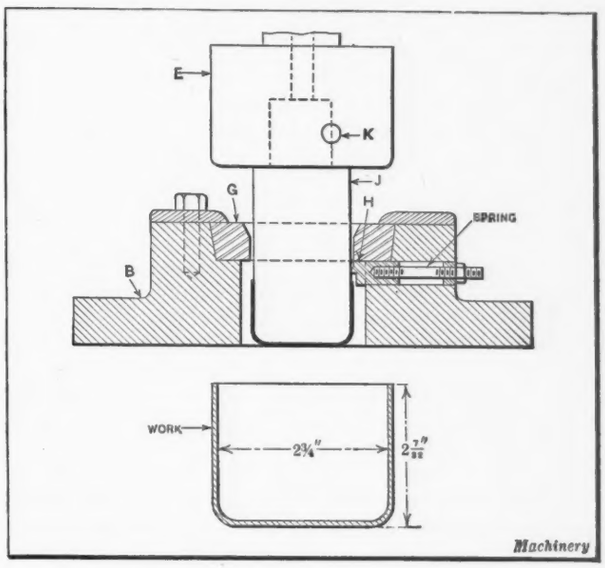


Fig. 2. Die for reducing the Diameter of the Shell

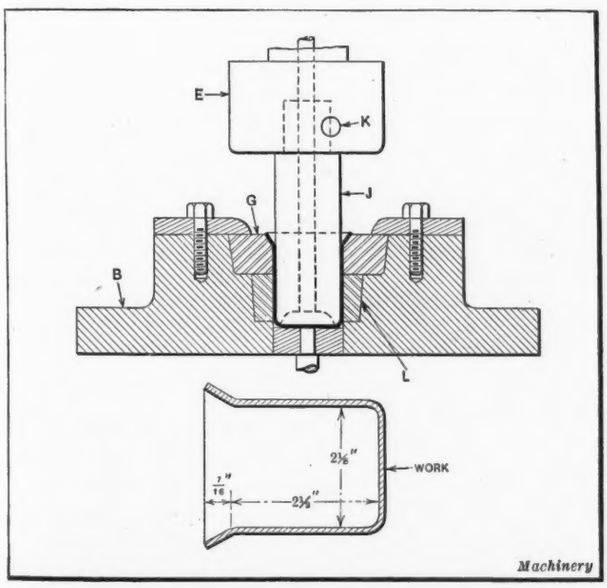


Fig. 3. Die for further reducing the Shell Diameter and partially forming the Flange

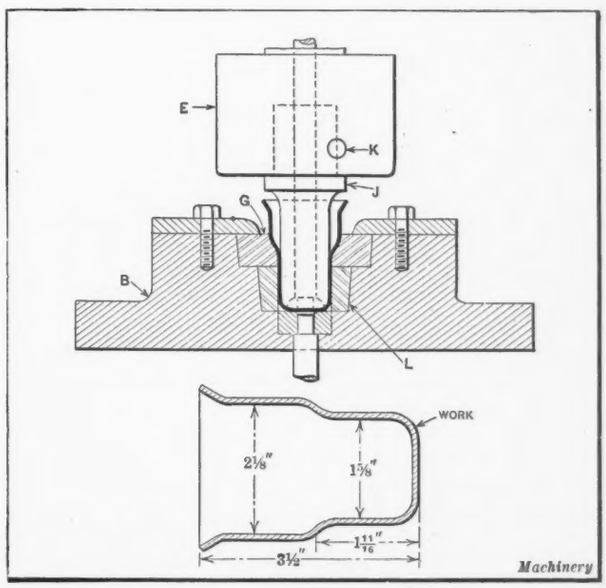


Fig. 4. Die for the Fourth Operation which elongates the Shell and forms the Small End

The die shown in Fig. 1 is a combination die which cuts the blank and performs the first drawing operation. It consists of a forming die *A*, die-block *B*, drawing ring *C*, cutting ring *D*, punch *E*, and shell ejector *F*. The construction of the parts and their method of operation can be readily seen from the illustration, and no further explanation is required. A plain push-through die, such as shown in Fig. 2, is employed to partially reduce the diameter of the shell. The die ring *G* is carried in the die-block *B*, in which it is secured by means of cast-iron straps and cap-screws. An interesting stripping device is used in this die. There are three strippers *H*, which are set radially in pockets or channels, equally spaced underneath die ring *G*, and which engage the end of the shell upon the return stroke of the press and strip the completely drawn shell from the punch. These strippers operate in the following manner: As the punch forces the shell downward, the strippers are pushed radially away from the center of the die, and when the upper end of the shell has passed the strippers, coil springs expand and force the ends of the strippers against punch *J*, so that upon its return stroke the shell is pushed from the punch. This

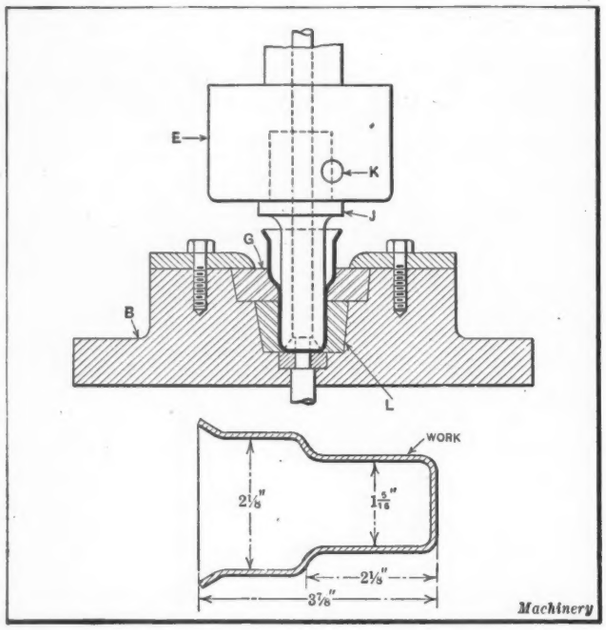


Fig. 5. Punch and Die of Similar Construction to that shown in Fig. 4

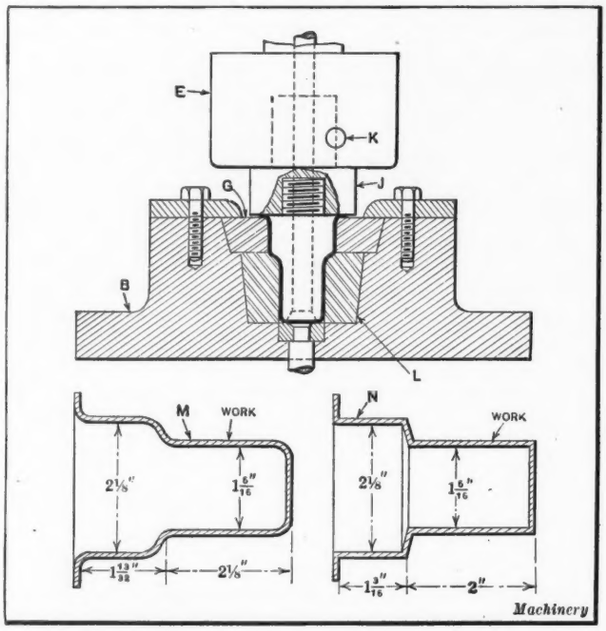


Fig. 6. Dies employed in performing the Final Forming Operations

die is so designed that it may be changed to suit various sizes of shells. To make this change, the strippers are adjusted and the punch and the die ring replaced to suit the work being formed. The punch *J* is supported in the machine steel punch-holder *E* by a ⅝-inch pin *K*, and when it is desired to use a different size punch it is only necessary to remove pin *K* from holder *E*, insert another size punch, and again drive pin *K* into place. The punch-holder *E* has a ¾-inch hole bored in it, which permits the use of a bar for forcing the punch from the holder. This type of punch and holder is used in five of the operations that are employed in the manufacture of this piece.

Fig. 3 shows a punch and die which further reduces the diameter of the shell and also partly forms the flange. Two die rings, *G* and *L*, are used in this die. The die that is shown in Fig. 4 is used for the first operation in forming the small end of the shell. The hole in ring *G* is enlarged on the top in order to receive the shell and at the same time to center it in the die. This hole is made with a rounded edge over which the shell may be nicely drawn. In Fig. 5 is shown another die which is used to reduce the small end of the shell; this is constructed and operated similarly to the preceding die, and therefore needs no additional description.

Fig. 6 shows the punch and die that forms the shell to the shape shown at *M*. By replacing the die rings *G* and *L* with two other die rings (not shown) and by changing the punch *J*, this die is also used to form the shell finally to the shape shown at *N*. It will be noted that the shell *M* is longer than the shell *N*, which allows the metal to be upset a sufficient amount to form the sharp edges, and at the same time does not alter the thickness of the walls of the shell. The die rings *G* and *L* are tapered so as to be a good fit in the die-blocks. This construction reduces the possibility of the dies breaking under unusual strains such as would occur if the operator should put two shells into the die at one time.

The trimming die shown in Fig. 7 trims the flange of the shell. This is a plain blanking die, and has the pilot *O* inserted into the punch to locate the shell properly upon the face of the cutting ring *D* while it is being trimmed. As this pilot is concentric with the outside of the punch, it brings the flange of the shell concentric with the body.

Toledo, Ohio J. BINGHAM

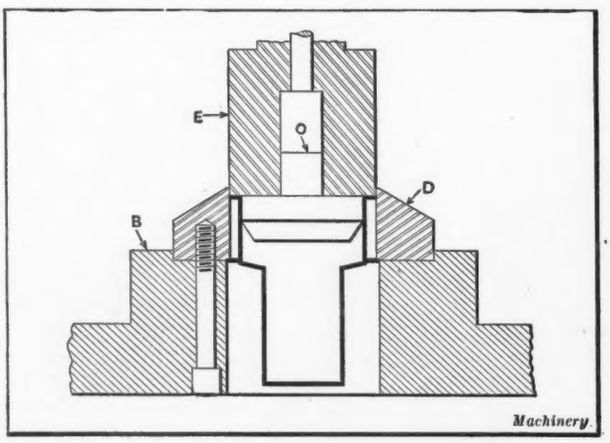


Fig. 7. Punch and Die which trim the Flange of the Shell

MAKING PROVISION FOR FACTORY ENLARGEMENT

In planning the building and operation of new shops, it is generally desired to have them so constructed and managed that the maximum amount of efficiency will result. The suggestions presented in this article were made by one of the executives of a large manufacturing concern and are ideas that were incorporated in an addition to his plant. Probably these suggestions will be of value to other executives who are planning shop enlargement.

The shop superintendent's office should be centrally located and raised above the floor so that it will overlook the entire shop. The assistants of the superintendent and the material routing department should be in an office adjacent to the superintendent's office. This location allows easy access to those in authority. The time clocks should be placed in the vicinity of the superintendent's office so that a close watch may be kept on all employes. A large number of washrooms and drinking fountains should be located around the shop so as to keep the men close to their work. If possible, the washrooms should be raised above the floor in order to save space and permit a clear view through the building.

The floor space of the shop should be as nearly square as possible, because this permits a large area to be overseen easily. It also shortens the haul of material. Moreover, it makes it possible to install a number of traveling cranes parallel to each other so as to permit the use of a crane by each comparatively small force of men, thereby eliminating loss of time in waiting for a crane. This saving in time cannot be accomplished by using two cranes on the same runway because it is impossible to prevent the cranes from becoming

congested at one end of the shop. Long craneways also require the use of crane operators which is a constant and heavy pay-roll expense.

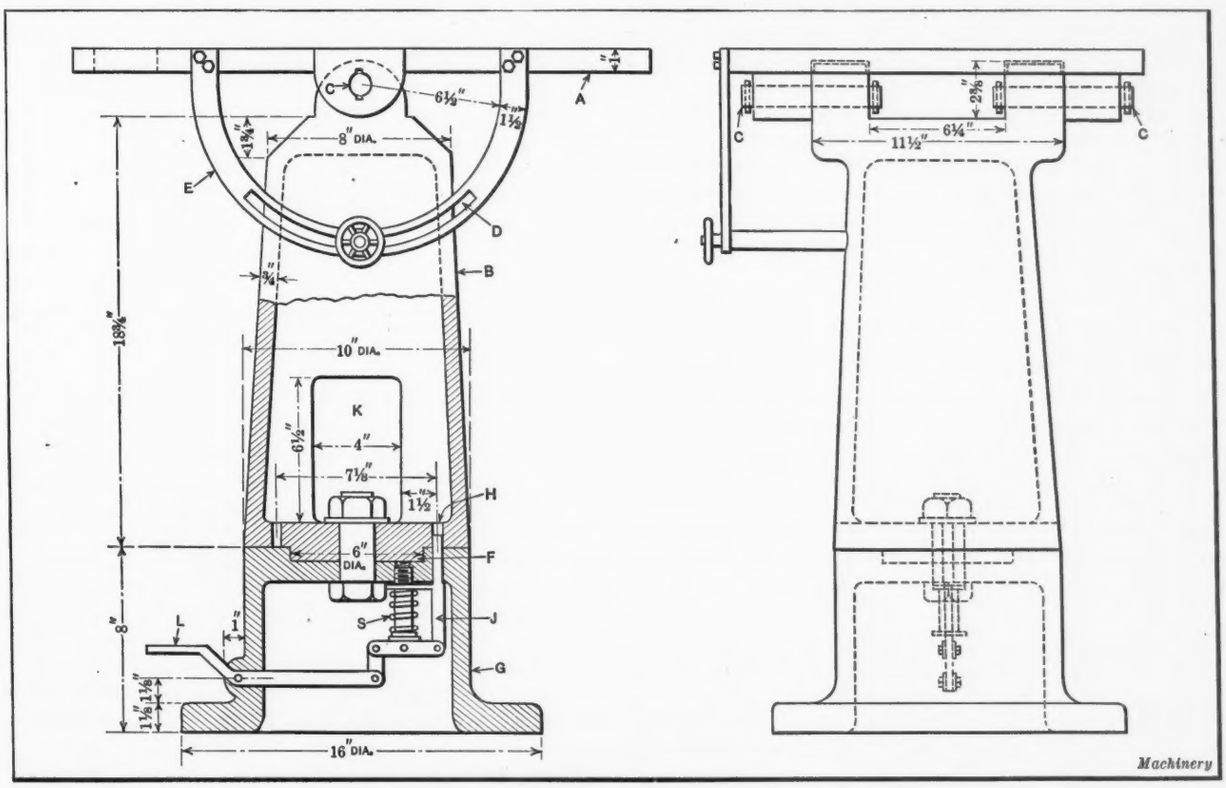
The gangways of a machine shop should be about 8 feet wide. If possible, the roof should be of sawtooth construction, but if this construction is not used there should be an abundance of skylights. All windows should extend from the ceiling to within a few feet of the floor. Storage bins should not be more than 8 feet high, because material which is stored in bins higher than this is seldom touched and is usually soon forgotten.

Probably the type of crane best adapted for yard purposes is a horizontal boom crane equipped with a self-propelled trolley that runs in and out on the boom. The crane should be so located that the trolley can run off the end of the boom to tracks inside the building. The advantages of this arrangement are that the load may be picked up inside the building and deposited in the yard without unslinging and reslinging. An automatic safety stop should be provided at the end of the boom to prevent the trolley from accidentally dropping off. A turntable is better than a switch inside a building because it requires only about half the space.

The allowance of space around other machines may be less, as their work usually comes to them in a fairly even stream.

In large plants, the shop should consist of two or more separate and distinct parts, each having its own head or general foreman and each general foreman having his own foremen. There should be no "straw" bosses or sub-foremen. None of these departments should have anything to do with each other, each arriving at a means of efficiently and rapidly producing a large total tonnage in its own way. This method will permit the same directness and closeness of authority between the shop executive and his men that exists in small shops and should be a stimulating factor of competition between the various departments.

In order to obtain the best results, a foreman should not have more than ten men under him, and each foreman should have complete authority over the work just as though it were his own shop. He should not be handicapped by interference from another foreman. In many plants, the foremen are so crowded with work because of the total tonnage and all the connecting details that must go through their hands that there is little time left for looking after other small matters. These matters are thus often taken



Stand to which Air Pumps are clamped when being repaired

There should be enough space around each machine for several days' supply of material, because a routing department generally cannot work closer than that, and in order to obtain the maximum production, machines must be crowded with work. In shops where several machines perform different operations on the same piece of work, a number of machines should be placed around one common open space. The open space is used for the storage of several days' supply of work and the output of the machines. This system saves space because the machines, which are not crowded with work, can give up their section of the common storage floor to the machines that are overcrowded. Handling expense is also saved, as the machines so arranged obtain their work from a common area, and when any machine has completed its operation on the work the piece is returned to this area where it can be easily procured by the operator of the next machine. Unnecessary trucking from one part of the shop to another is thus eliminated. Ample space should be allowed the machines where the work starts, because their supply of material is often irregularly furnished.

care of by inefficient under-bosses, resulting in expensive leaks that may not be discovered for years.

Indianapolis, Ind. STUART DEAN

* * *

AIR PUMP REPAIR STAND

For performing machining operations that are necessary when making repairs on air pumps, a suitable table or holding stand will greatly facilitate the performance of the work. Such a stand is here illustrated and described. The surface plate *A* is made of cast iron. It is finished on the top and contains two sets of bolt holes, so that one plate may be used for holding two styles of pumps. This surface plate is attached to the column *B* by means of two pins *C* which pass through lugs on the two parts. This construction allows the surface plate to be tilted as required, when repairing the pumps, to any angle in either direction within the scope of slot *D* in the U-shaped arm *E*. A handwheel is provided for clamping the plate in the desired angular position.

The column *B* is of box section, and on its lower part has

a circular boss *F* which fits into a similarly located recess in the base *G*, in which it may be revolved. There are four equally spaced index holes *H* in the column and an index plunger *J* in the base. This plunger may be withdrawn from an index hole by pressing down on the foot-treadle *L*. After the column has been turned through 90 degrees, the treadle may be released, and the plunger, actuated by the expansion of the coil spring *S*, will enter one of the holes in the column. The base and column are secured together after the latter has thus been accurately indexed, by means of a bolt and nut as shown. A hole *K* is cast in the column which permits of ready access for tightening or loosening this nut.

M. K.

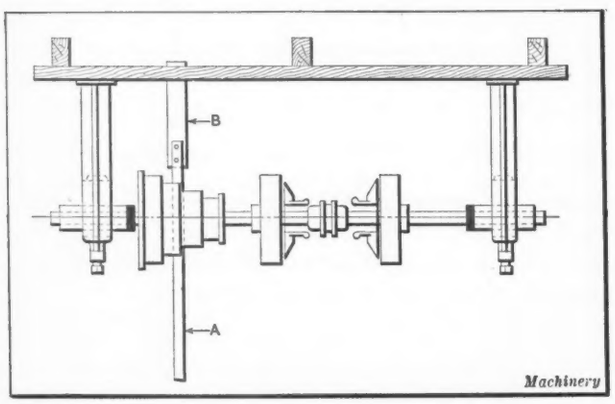
THE SOCIETY OF MECHANICAL INSPECTORS

It affords me real pleasure to note in the July number of MACHINERY, page 1100, that the American Society of Mechanical Inspectors has been formed. I have specialized in inspection work for the last five years, and urged the formation of just such a society in the technical press quite some time ago. In an article in MACHINERY, June, 1917, page 910, I advocated the formation of an inspectors' society, and it would have been of great value if formed at that time. Now the war is over and the consequent pressing demand for men with experience and ability as good inspectors is lessened. Had this society been organized before the United States entered the war, the manufacturers throughout the country would have been able to apply to some central agency or bureau, such as the society, and a great deal of time, labor, and materials, all of which were badly needed during the hostilities, would have been saved.

Stoneham, Mass. RUSSELL R. UX

BELT POLE FOR ENGINE LATHE

Shifting the belt on the cone pulley is a regular performance for a lathe operator and involves the loss of much time if an ordinary belt pole is used. It often happens, in cases where one pole is provided for a number of machines, that the operator is obliged to wait until someone else is through using the pole, or to spend considerable time trying to find one. This may occur when there is a rush job in process,



Belt Pole attached to Countershaft Joist for shifting Belt on the Cone Pulley

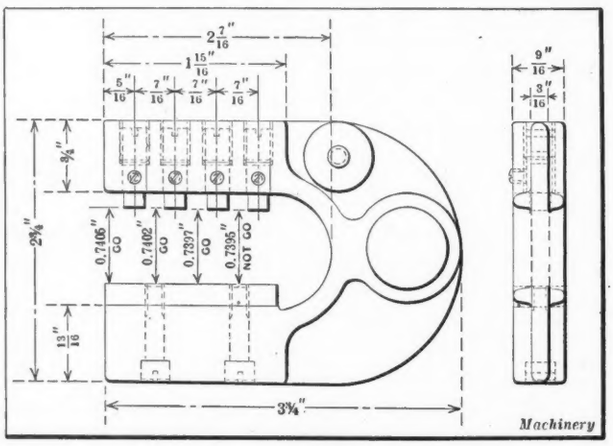
in which case the operator usually resorts to the use of his bare hands, with the probable result of injury, either by friction or by a protruding belt hook.

The accompanying illustration shows a pole which is attached overhead on the cross-beam at the rear of the lathe, thus being available at all times. It consists simply of a plain, cylindrical stick *A*, hung by a leather strap *B*. This simple arrangement will save much time in a day, being always in close proximity to the operator and at the same time reducing, if not entirely eliminating, the possibility of injury. In the event of the machine having a thread-chasing dial, in which case it would not be necessary to reverse the drive, a higher degree of lathe efficiency can be obtained by making use of the countershaft clutch pulleys for changing the speed. These clutch pulleys should be belted to pulleys on the main shaft, so as to produce a speed which will be intermediate between the speeds obtained by the two steps of the cone pulley that would otherwise be employed.

Trail, B. C., Canada JOHN HOMEWOOD

FOUR-POINT LIMIT SNAP GAGE

The limit gage here illustrated has four adjustable gaging points, and is particularly adapted for use on such work as sorting ground pins and roller bearings, which must be machined to very close limits. The general design of the gage is not unlike the standard commercial product which may be purchased on the market, the construction of which is quite well known. The body is made of cast iron, and



Four-point Limit Snap Gage for Special Use on Accurate Work

contains a hardened and ground tool-steel block as a gaging surface and adjustable gaging points which are made of hardened drill rods.

In gaging needle-bars, the operator uses the gage to sort the work as it comes from the grinding machine. The first two points gage bars which come within the larger limits, and this work is separated from that which comes within the limits of the next two points, thus making two assortments, the needle-bars in each of which are within the close limits of the gage. Of course the bars which pass through the "Not Go" gaging point—0.7395 inch—will not be used in any case. This inspection of the work after grinding separates the bars so that the amount of lapping required on the hole in which the bar fits is reduced to a minimum. It will be seen that much more time would be required if two separate gages were used. If desired, two entirely different sizes of work may be handled on this gage in like manner.

Buffalo, N. Y. H. KURZWEIL

REPAIRING A SLIDE-RULE RUNNER

When repairs are needed on slide-rules, much time is often lost by having to resort to "long hand" methods of making calculations until the rule has been sent to the nearest engineering supply house for repairs. This is especially true when engineers are engaged in field work or stationed in the smaller towns and cities. The writer has occasionally repaired slide-rules when the runner glass has been broken, by substituting a piece of celluloid cut from a triangle. The most transparent celluloid should, of course, be used when obtainable, but in case of real necessity almost any available triangle may be used. The scribing of the hair-line may be done with a safety razor blade, although other suitable means will doubtless suggest themselves. The runners which have been repaired in this manner have generally proved satisfactory in an emergency, and have saved much time.

Decatur, Ill. WARREN ICHLER

HOW AND WHY

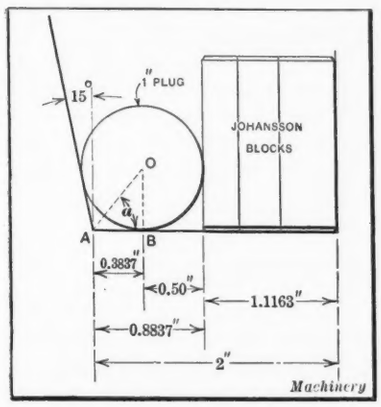
QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

A TOOLMAKER'S PROBLEM

J. A.—Will you kindly show me how to find the correct diameter of a plug which will be tangent to the sides of a snap gage, as shown in the illustration? The 2-inch dimension and the 15-degree angle are all that are known.

ANSWERED BY ELMER C. COOLEY, SYRACUSE, N. Y.

The answers to this problem which have been published in previous numbers of MACHINERY have adhered strictly to the question asked—that is, how to find the diameter of a plug which will be tangent to the sides of the gage. The simplest and most practical way to check this gage, however, is to use a 1-inch standard plug and Johansson gage-blocks. By this method, only one computation is necessary—a fact which will appeal to the average toolmaker.



Checking a Snap Gage by Means of a Standard Plug and Size Blocks

Referring to the accompanying diagram, lay the plug in the gage against the surfaces forming the 105-degree angle.

$$a = \frac{105 \text{ degrees}}{2} = 52 \text{ degrees } 30 \text{ minutes}$$

$$AB = OB \cot a$$
$$= 0.50 \times 0.76733$$
$$= 0.3837 \text{ inch}$$

Subtracting the sum of 0.3837 inch and the radius of the plug 0.50 inch, from the known dimension 2 inches,

$$2 - (0.3837 + 0.50) = 1.1163 \text{ inches}$$

The total width of gage-blocks to use when checking this gage should then be equal to this dimension.

COMPENSATING FOR ERRORS IN A LATHE LEAD-SCREW

W. M.—Is there any way to compensate for errors in a lathe lead-screw?

A.—Errors in a lathe lead-screw may be compensated for by equipping the carriage with a special lead-screw nut, which may be turned slightly forward or backward when cutting a precision screw, in order to advance or retard the movement of the carriage and thus counteract the errors in the lead-screw of the lathe. The rotary movements of the nut are regulated according to the errors in the lead-screw, and may be controlled by a templet which causes a lever connecting with the nut to be raised or lowered as the carriage traverses along the bed. While this method of compensating for errors is simple in principle, it is not easily applied because of the difficulty of determining the location and magnitude of the local errors along the lead-screw, which should be cut as accurately as possible to begin with, if intended for a precision screw-cutting lathe. The general method of locating the errors is by comparing the movements of the carriage derived from complete turns of the lead-screw, with a very accurate scale of the kind found on some measuring machines. The templet for controlling the rotary movements of the lead-screw nut is then laid out according to the errors at different points along the screw.

PRODUCTION PROBLEM FOR THE MACHINE SHOP

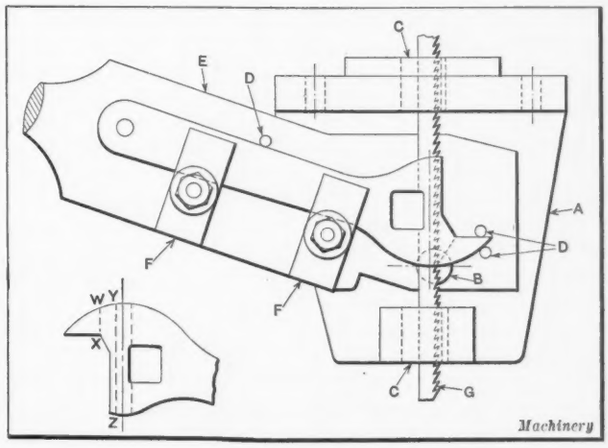
M. M. S.—What is the best method to employ, on a production basis, in removing stock from a wrench head in which the movable jaw of the wrench operates, as shown in the illustration on page 1086 in the July number of MACHINERY? The stock removed forms a slot which cuts into the previously drilled hole for the jaw rack.

ANSWERED BY GEORGE E. HIEBER, CINCINNATI, OHIO

This production problem can be solved by broaching, either as the wrench head is designed or by making a slight change. The piece would be better adapted for quantity production if the slot were made so as to run parallel with the drilled hole, as shown at *WXYZ* in the illustration. This change, which would not greatly weaken the jaw of the adjustable wrench, would permit the introduction of a pull broach having a bearing in the drilled hole. A simple work-holding fixture could then be used, insuring maximum production.

If the slot must be made as shown in the original illustration, the broach and fixture can be constructed as shown in the accompanying illustration. *A* represents the base of the fixture. This base carries the pin *B* and two broach-supporting bushings *C* located as shown. A work-holding arm *E* pivots on pin *B*, and may be swiveled by hand. The wrench is located in the holder by means of three pins *D*, and is secured in position by the clamps *F*. The points of the teeth of broach *G* are in a plane parallel with the back of the broach; the sides are taper-ground, the cutting edge being thicker than the back edge, so as to provide side clearance.

The method of performing the operation is self-explanatory. It must be apparent that even with hand feed trouble



Method of machining Wrench Slot by broaching

is likely to be experienced through broaches breaking due to their not being supported on the back while making the cut. The previously suggested change in the shape of the slot would eliminate this trouble.

THE GROWTH OF CAST IRON

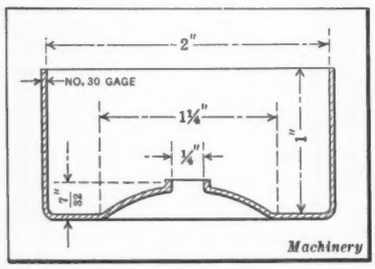
D. A. W.—Under what conditions will cast iron "grow" or increase in size?

A.—The "growth" of cast iron is the result of repeatedly heating and cooling the cast-iron parts. For instance, cast-iron annealing ovens originally 8 feet in length have grown to a length of 9 feet as the result of being kept red-hot for

prolonged periods between which they were permitted to cool. Cast-iron furnace grates and other parts subjected to alternate heating and cooling are also frequently distorted and sometimes broken because of the growth. To avoid this growth or increase in size as far as possible, white cast iron having a carbon content of about 3 per cent and a relatively small amount of silicon and other impurities should be used.

DRAWING A BRASS SHELL

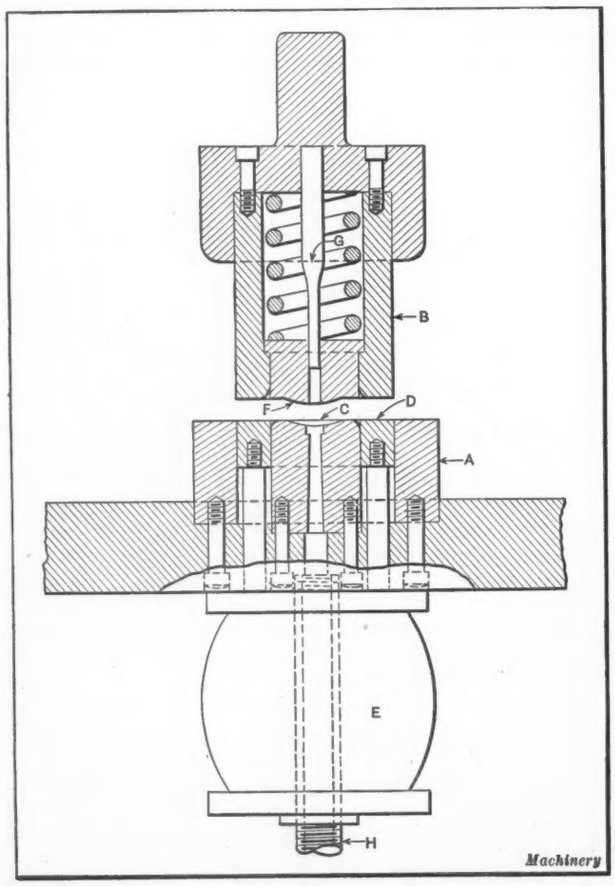
R. W.—A cup of the dimensions shown in the accompanying illustration is to be drawn. Can any reader of MACHINERY that has performed drawing operations on cups of this or similar shape furnish illustrations and descriptions of the dies that have actually been used in performing the work? The material is brass, No. 30 gage. The tools should preferably be designed for a single-action press.



Cup-shaped Brass Shell to be drawn on a Single-action Press

ANSWERED BY R. P. DEANE, HOLYOKE, MASS.

Provided the stock is soft enough to be drawn in a single operation, a combination blanking and forming die like that shown in the accompanying illustration might be employed to form the shell. The operation of the punch and die needs no detailed description, as it functions similarly to that of other drawing tools of like design. As may be plainly seen by referring to the illustration, the ring or blanking die *A* is set into the bolster plate, in which it is fastened by means of fillister-head screws. The combination blanking and forming punch *B* is similarly secured to the punch-holder, the edge of the outside diameter being made sharp while the interior edge is rounded and polished, so that it will draw the blank over the rounded edge of the forming die *C*. Die *C* is slightly cupped out at the top to the shape of the bottom of the shell to be drawn, and has a central hole, enlarged at the top, through which punch *G* operates. Between the blanking die *A* and the forming die *C* there is a combination pressure ring and stripper *D*, which has a rubber bumper attachment *E*, with supporting plates and drawing pins.



Combination Blanking and Forming Die used to make a Brass Shell

The upper part of pressure pad *F* has a shoulder by means of which it is carried in the hollow forming punch, its function being to form the concave bottom of the shell. For this purpose the pad is backed by a coil spring, heavy enough so that after the concave bottom is formed, the spring will hold the pad firmly against the shell while the punch *B* continues downward, forming the work. Before the operation is completed, punch *G* comes into contact with the shell, first forming the small boss into the enlarged end of the hole in the forming die, and then punching out the ¼-inch hole in this boss as the ram of the press proceeds to the end of its stroke. On the upward stroke of the press, ring *D*, which has been forced below the end of the shell, will be moved upward by the expansion of the bumper *E*, thus ejecting the shell. The center stud, or attachment screw *H*, of the rubber bumper, should be made of ½- or ¾-inch extra heavy iron pipe, so as to allow the punchings from the small hole to drop through the die.

PROBLEM IN MENSURATION

In a previous number of MACHINERY, a problem was presented in which it was required to determine the diameter of a circle from the two dimensions given in the accompanying diagram. The previous solutions of the problem involved the use of quadratic equations. The problem may be solved, however, by means of plane trigonometry—a subject with which toolmakers are more familiar. By the conditions of the problem, $AB = \frac{1}{4}$ inch, and $BC = 1$ inch. Therefore:

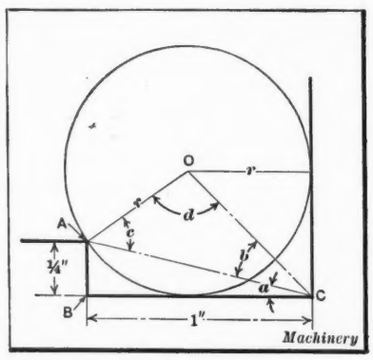


Diagram used in solving Problem

$$\frac{AB}{BC} = 0.250 = \tan a$$

$$a = 14 \text{ degrees } 2 \text{ minutes } 10 \text{ seconds}$$

and

$$b = 45 \text{ degrees} - a = 30 \text{ degrees } 57 \text{ minutes } 50 \text{ seconds}$$

$$AC = \sqrt{(AB)^2 + (BC)^2} = \sqrt{1.0625} = 1.0308 \text{ inches}$$

or

$$AC = \sec a \times 1 \text{ inch} = 1.0308 \text{ inches}$$

From a corollary in mensuration, page 128, MACHINERY'S HANDBOOK, $OC = 1.414r$. According to the law of sines:

$$\frac{r}{1.414r} = \frac{\sin b}{\sin c}$$

from which

$$\sin c = 1.414 \times \sin b = 0.7275$$

and

$$c = 46 \text{ degrees } 40 \text{ minutes } 39 \text{ seconds}$$

Therefore

$$d = 180 \text{ deg.} - (b + c) = 102 \text{ deg. } 21 \text{ min. } 31 \text{ sec.}$$

Then

$$\frac{r}{AC} = \frac{\sin b}{\sin d}$$

from which

$$r = \frac{AC \sin b}{\sin d} = \frac{1.0308 \times 0.5145}{0.97683} = 0.5429 \text{ inch}$$

and the diameter of the circle, $2 \times 0.5429 = 1.0858$ inches.

Philadelphia, Pa. FRED J. NAAB

Standardized Gages for Interchangeable Manufacture

First of a Series of Articles Dealing with Modern Inspection Department Practice and Principles of Gage Design, Including a Complete Tolerance System for Gages, Designed Especially for Interchangeable Manufacture

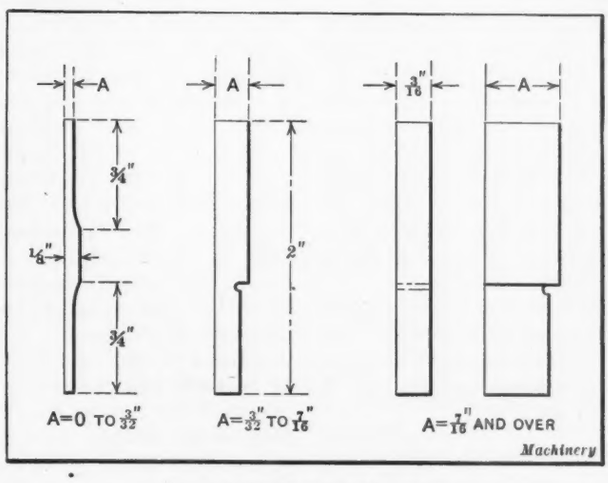
By JOHN E. COLLINS

GAGES are one of the many things that received their greatest impetus during the recent war. All the large war contracts for munitions awarded by the Ordnance Department, stipulated that all parts must pass the gages furnished by the department to the contractor for inspection. These gages were of various designs—good, bad, and indifferent. A gage that is correctly designed does not need lengthy instructions relative to its use or explanations as to the allowable limits. A gage should be so simply designed that there can be no mistake in its use. The limits should be definitely predetermined, and the allowance should be stamped on the gage itself, thereby preventing possible misunderstandings.

After the United States entered the war, a special gage division was organized in Washington, D. C., for designing all gages for materials ordered by the Ordnance Department. Many manufacturers also furnished their own working gages, made either to the designs furnished by the Ordnance Department, or to designs of their own. The experience thus gained has had an important influence upon the development of gage design and gage making. The selection of materials used for gages is more carefully considered than formerly, and the requirements as to workmanship and heat-treatment are better understood. Gages that are poorly designed and made are expensive, because they make proper inspection impossible. The production of war materials brought out the fact that a complete system of standard gages of specific designs is necessary in order to produce the best results. The lessons taught by the war are applicable to the whole machine-building trade. The present and succeeding articles are based upon these lessons, and it is the intention of the author to place on record in this series a set of standards for gages that is applicable to the production of any part for any mechanism.

Classification and Definition of Gages

Working gages are those which are used in testing the work for size during the actual manufacture of the part. This type of gage has a greater amount allowed for wear than any other type, and hence the actual tolerance on the work between the maximum and minimum gage is smaller, by the amount allowed for wear on the gage, than the actual amount specified on the drawing. As this type of gages wear, they become useless as working gages, but may then be used for inspection gages. When they have worn so that they are of no further use as inspection gages, they are either discarded or may be retained to be used as master inspection gages.



Standard "Checks" for Snap Gages

Inspection gages are used by the inspector for checking the product. These gages are generally of the same design as the working gages, except that they have a much smaller allowance for wear.

Master gages are used only for verifying inspection gages, or for checking the product in case a disagreement arises between the manufacturer and the purchaser. Under the heading "master gages" are included various gages known as "checks," "masters," and "reference gages." Master gages should, if possible, be of the same design and construction as the inspection gages, but should have practically no allowance for wear. In some cases, checks or masters are made which are complements or the reverse of the inspection and working gages, as, for example, thread ring gages which are used for plug thread gages. All snap gages gaging below ¼ inch, and those so designed that they cannot be checked by ordinary measurements, should be provided with checks that are the reverse of the inspection gage itself.

Master gages are of double importance to the manufacturer who has part of his product made outside of his plant, because occasions will arise when his own inspectors will reject work that the outside manufacturer claims to be correct. One set of masters should be kept at the outside manufacturer's plant and one at the home plant.

Gages that are used for checking other gages are sometimes erroneously termed "reference gages," but such gages should be called "checks." Reference gages, in the true meaning, are standard ring, plug, and end-measure gages, such as may be considered standards of measurement, and which are made by several prominent tool manufacturers. These gages have practically no allowance for wear, and are expected to be accurate to standard size within 0.0001 inch or less. These gages are used as ultimate standards of reference in producing other measuring instruments.

Checks perform an entirely different function in a gaging system, but are not yet used as extensively by manufacturers as they should be. Checks are simply standards for the inspection of wear of working and inspection gages. They indicate when the gages are so worn by use that they are no longer suitable for the purpose for which they are intended. Checks may be used for a considerable number of gages, but are necessary in the case of many types, such, for example, as ring or snap gages which are too small to be measured by ordinary methods. A type of standard checks for snap gages is shown in the accompanying illustration. For ring gages, a standard plug furnished with a handle is used as a check; and for profile or similar gages, a master profile of the work itself is recom-

mended, as in this way the profile of the working and inspection gages can be most readily inspected.

The terms "limit," "tolerance," "allowance," and "clearance" have been repeatedly defined in MACHINERY, and there is no need to repeat the definitions. It is expected that anyone interested in this series of articles is familiar with the meaning of these terms.

Wear and Life of Gages

The number of times that a gage may be used on the work before being worn beyond the required limits varies according to the material being gaged. Some materials, such as cast iron, have high abrasive qualities and wear the gage much more rapidly than steel, bronze, or brass. Aluminum also wears gages very rapidly. It has been found by actual trial that a gage when used on 10,000 pieces of aluminum will show a wear on the gaging surface of about 0.0005 inch. It was also found that 50,000 pieces of brass or bronze could be gaged before the wear on the gaging surface amounted to 0.0005 inch, while the gaging of from 18,000 to 22,000 pieces of cast iron produced the same amount of wear. These figures will vary somewhat, depending on the grade of finish on the work, the diameter or length of the piece, and the material of which the gage itself is made. A ground surface is the most satisfactory gaging surface from the standpoint of long gage life, as 60 per cent more pieces can be gaged before the surface will wear down to the same dimensions to which it would have worn if used on turned work.

Hardness

The actual gaging surfaces of all gages should be tested for hardness. The degree or amount of hardness should be specified on each gage drawing, and the gage should then be inspected by the tool inspection department to ascertain if the required hardness is attained. The gages are tested either by the Brinell or the scleroscope tests. When the hardening process is checked by means of the scleroscope, the note on the drawing might read, for example: "Scleroscope test 60 to 70." A description of the Brinell and the scleroscope tests and a comparison of the test numbers are given on pages 1161 to 1164 of MACHINERY'S HANDBOOK.

The exact degree of hardness desired for gages varies, but the general practice is to call for a minimum scleroscope hardness of 80. This assures that the gage will be hard enough to "stand up," and at the same time it gives the heat-treating department some leeway in the hardening process. Tool steel may be hardened until the scleroscope will give a reading of from 90 to 110, but this is too hard for gages as it makes the steel very brittle. If a gage, hardened to the maximum hardness that tool steel will attain, should be accidentally dropped on a hard surface, it would probably be broken. It is, of course, an easy matter to draw the gage slightly, thus relieving the structural stress in the brittle steel and prevent this occurrence.

Seasoning or aging the steel brings about the condition of permanency which hardened steel will reach after a period of time. This is a condition of stability caused by the stresses in the steel having adjusted themselves and become "set." The hardening of steel sets up serious stresses in the metal; therefore, all gages that are hardened should be laid away for a few months before the finish-grinding and lapping operations are performed. All stock should be annealed before machining. This is important, as most of the steel used for gages is cut from stock which has been rolled to shape. In order to remove the stresses incident to rolling, as well as to make the structure of the steel more homogeneous and soften the metal, it is best not to neglect the annealing. The saving in the cutting tools and milling cutters alone will more than offset the expense, not considering the risk of having an intricate gage crack in hardening.

Extent to which Machine Parts should be Gaged

The first determining factor in gaging depends upon the extent to which the parts are to interchange. Whether or not the parts should be interchangeable is determined by several factors: First, the quantity of parts to be manufactured, second, whether or not units or machines are to be shipped as assembled parts that have been fitted in the shop, or whether they are to be assembled afterward from parts which have no predetermined relation to one another; third, the extent to which the parts are likely to be replaced due to wear or breakage; fourth, whether the type of machine is likely to be used as a permanent type, and consequently be continually in the process of manufacture.

In considering to what extent one should go into the gaging of any machine, it is the opinion of the writer that, if a machine is to be shipped as an assembly and is not to be manufactured either continuously or in comparatively large numbers, the inspection of the parts, while in the process of manufacture, as to workmanship and fit and to insure the proper functioning of all parts affected, is all that is desirable. This will not insure interchangeability, and if a part is worn out, the new part must be made to fit, which may necessitate the shipment of the casting or material to the machine to be fitted on the spot.

There is an intermediate step between complete interchangeability and the fitting basis of manufacture. This step is that of predetermining from practice or logic what part or parts are most likely to wear and then making these parts interchangeable. This practice will permit these pieces to be carried as extra parts and assembled without fitting. If this intermediate step seems to be the proper method, the question arises as to the extent to which it is advisable to go into the gaging problem. For instance, should the inspectors be furnished simply with standard measuring instruments (wherever such are applicable), pin gages, standard commercial plug gages and thread gages (so as to require the design of gages for only those parts for which a commercial gage is not obtainable), or should rings and plugs and special gages be designed as well? All these conditions should be definitely settled before a machine is ordered to be "gaged up."

Each gage should be marked by the manufacturer with the following: (1) The name of the part to be gaged; (2) the prescribed maximum or minimum gaging dimensions with the words "Go" and "Not Go," as the case may be; (3) if a left-hand thread gage, the word "left"; (4) the name of the manufacturer or his initials; and (5) a serial number assigned to the gage. The standard temperature for all gages should be 68 degrees F.

* * *

FOREIGN SCHOLARSHIPS FOR AMERICAN STUDENTS

The American-Scandinavian Foundation, from its headquarters in New York City, has announced the establishment of ten new scholarships, beginning with the academic year 1919-1920, for young American scientific students to complete their general study and research in Sweden, in the universities and technological schools there and under the direction of scientific specialists in industry. This scheme of scholarships is in keeping with the avowed purpose of the foundation "to draw the American and Scandinavian peoples closer in bonds of intellectual kinship," and was initiated by Axel Robert Nordvall, Swedish commissioner to the United States, and Dr. Henry Goddard Leach, secretary of the foundation. The funds necessary to maintain the scholarships have been pledged by Americans who desire to promote the interchange of scientific and technical knowledge between the two countries and wish Sweden to understand American ideals better. Similarly, funds are being raised in Sweden to send ten Swedish students to the United States for scientific and engineering studies. Each scholarship will provide $1000 for one year's study. The definition of subjects is not strictly limited, but the scholarships will be proportioned among those studies in which Swedish science offers unusual advantages,—physics and chemistry, hydro-electrical engineering and metallurgy.

The Machine Tool Trade

MOST of the machine tool manufacturers are very busy, dealers in various parts of the country reporting that they have great difficulty in securing early deliveries of many classes of machines, mentioning especially automatic screw machines, grinding machines, milling machines, shapers and presses. One of the largest machine tool companies in the country is sold out so far ahead that quotations are not made on delivery for stock orders.

Machine dealers state that they are obtaining a satisfactory volume of business from the automobile industry, although but one of the large automobile companies has placed any very big orders. One of the large automobile concerns has obtained a great deal of equipment through the purchase of government-owned machine tools. Considerable agitation is reported among labor, in some states agitators being very active, but it is believed that the more mature and conservative among the men in the shops will be able to counteract these influences. Men familiar with the conditions look for small strikes here and there, but do not expect any general or widespread labor trouble.

There is a great deal of development work still going on in the machine tool industry, machines with new features and labor-saving devices constantly being brought out. Several radical departures in designs have been made, some of which have already been described in mechanical journals, while others are not yet made public. Some of the new designs appear to be great innovations and will aid in advancing the machine tool development to a marked degree.

Foreign Trade in Machine Tools

The accompanying table shows the value of exports of metal-working machinery from the United States to foreign countries during the month of July, as published by the Department of Commerce. As will be seen, the total value of the machine tools exported amounted to about $2,380,000. England, as usual, was the biggest customer, taking nearly $1,000,000 worth of machine tools. France and Belgium were the two next best customers, France buying more than $500,000 worth and Belgium nearly $275,000 worth. Of metal-working machinery other than machine tools, France was the largest customer, England took the second place, and Belgium the third, with, respectively, about $600,000, $500,000 and $300,000 worth of machinery.

EXPORTS OF METAL-WORKING MACHINERY FROM THE UNITED STATES, JULY, 1919

Countries	Lathes	Sharpening and Grinding Machines	Other Machine Tools	All Other Metal-working Machinery
	Dollars	Dollars	Dollars	Dollars
Azores and Madeira Islands	.....	290	.....	.....
Belgium	174,435	43,278	53,284	287,041
Denmark	5,934	9,931	18,136	36,403
Finland	.....	.....	591	.....
France	107,663	174,644	235,944	612,235
Greece	333	.....	1,556	75
Italy	8,136	8,601	29,250	68,577
Netherlands	11,157	3,900	7,051	21,840
Norway	7,412	1,078	12,781	11,338
Portugal	108	110	.....	805
Russia in Europe	.....	.....	436	.....
England	335,390	100,334	558,795	481,179
Scotland	.....	.....	17,068	791
Ireland	.....	.....	1,875	.....
British Honduras	.....	.....	.....	65
Canada	27,225	17,485	50,285	86,741
Costa Rica	.....	223	.....	675
Honduras	954	.....	.....	.....
Nicaragua	.....	136	91	45
Panama	.....	.....	360	1,192
Salvador	.....	.....	18	.....
Mexico	.....	1,329	4,382	600
Newfoundland and Labrador	.....	.....	9	870
Barbados	.....	.....	108	.....
Jamaica	.....	.....	72	78
Trinidad and Tobago	558	21	.....	.....
Cuba	2,585	1,166	10,880	7,355
Haiti	.....	.....	.....	4,330
Dominican Republic	.....	.....	30	.....
Argentina	22,636	237	2,168	18,273
Bolivia	.....	.....	.....	7,805
Brazil	25,757	2,004	5,193	11,554
Chile	736	4,131	7,611	91,160
Colombia	50	233	145	96
Ecuador	.....	.....	602	183
British Guiana	200	.....	872	.....
Paraguay	.....	.....	.....	1,070
Peru	225	9,182	1,544	1,891
Uruguay	.....	.....	651	12,684
Venezuela	.....	.....	126	.....
China	555	3,046	2,007	4,777
British India	1,721	240	1,200	33,156
Straits Settlements	.....	.....	205	402
Other British East Indies	.....	666	.....	19
Spain	22,388	5,737	15,206	66,510
Sweden	19,208	29,341	10,402	66,376
Switzerland	2,343	585	405	24,441
Dutch East Indies	23,167	4,669	8,156	6,489
French East Indies	.....	.....	.....	2,912
Hongkong	.....	125	.....	.....
Japan	6,318	13,412	16,348	50,359
Russia in Asia	.....	.....	1,510	.....
Siam	.....	67	.....	.....
Australia	131	9,481	3,573	12,105
New Zealand	3,849	4,775	2,188	2,786
Philippine Islands	18,155	2,017	2,173	13,495
British South Africa	5,079	1,023	4,362	5,923
British East Africa	.....	.....	29	.....
French Africa	5,783	48	46	.....
Portuguese Africa	.....	.....	658	.....
Total	840,191	453,545	1,090,382	2,056,701 *Machinery*

The National Foreign Trade Council has called the attention of American exporters to the fact that correspondence from abroad indicates a difference of interpretation of the term "F.O.B. port." Foreign correspondents claim that American manufacturers and exporters misuse this term. The complaint is that American manufacturers who have quoted "F.O.B. New York" have interpreted that quotation to include merely delivery within the limits of the port of New York and not necessarily actual delivery on board the overseas vessel. The foreign contention is that the term "F.O.B. port" has only one meaning, namely, "free on board overseas vessel," at the port stated, and that a quotation "F.O.B. port" means that the purchaser has no charges to meet except those connected with ocean freight and insurance. It is evident that it would have an adverse effect upon American foreign trade if, after the American manufacturer quotes a price "F.O.B. New York," or other port, the customer still would have to pay charges for cartage, lighterage, storage, and other items which the foreign customer has understood to be included in the "F.O.B. port" quotation.

The secretary of the National Foreign Trade Council states that there is no question that the original meaning of "F.O.B. port" was "free on board ship," and that this is the general and usual interpretation among foreign buyers. It is furthermore pointed out that it is the best practice for American exporters and manufacturers to have their quotations mean "free on board overseas vessels," but in any event the quotation, whatever it is, should be unmistakably clear and explicit.

Machines for Trade Schools

On September 5, the House of Representatives passed the Caldwell bill authorizing the selling of the surplus machine tools in the government's possession to the trade, technical, and engineering schools of the country. Under this bill the secretary of war is authorized to sell at 10 per cent of their cost such surplus machine tools, now owned by the United States Government and under the control of the War Department, as are suitable for the technical and engineering schools, upon the application of these schools in writing. It is provided in the bill that if any such machines are later offered for sale by the educational institution to which they have been sold, without the consent in writing of the Secretary of War, then the title of the machines will revert to the Government.

Resumption of Trade with Hungary

The War Trade Board section of the Department of State announces that the resumption of trade and communication between the United States and Hungary has been authorized. Exports from the United States to Hungary will be controlled by individual export licenses, but such licenses will be issued freely upon application, except with respect to a number of commodities, the exportation of which will be restricted for military reasons. Imports into the United States from Hungary may be made under a general import license which permits importation without individual import license of all commodities except those specifically enumerated in paragraphs 1, 2, and 4 of the War Trade Board ruling No. 825, which may be obtained upon application to the Department of State, War Trade Board section, Washington, D. C.

Permanent Machine Exposition in New York

The opening of the permanent machine exhibition, known as the International Machine Exposition, in the Grand Central Palace, New York City, is set for October 15. The exposition will include exhibits of manufacturers and sales agencies of engine lathes, milling machines, planers, drilling machines, hand and power presses, bolt cutters, boring and turning mills, gear shapers, turret lathes, grinding machines, welding machines, automatic machines of various types, etc. Many of these machines will be shown in operation.

* * *

AMERICAN MALLEABLE CASTINGS ASSOCIATION

The American Malleable Castings Association, 1900 Euclid Bldg., Cleveland, Ohio, is endeavoring to establish standards of quality for the product of the members of the association. It has recently been announced that, in addition to the various laboratories maintained by the members of the association, a research laboratory is also maintained by the association as a whole, at Albany, N. Y., for investigation and experiment, and for the testing and analysis of the daily output of each member of the association. In this laboratory, partial tests are made, and the results, together with directions for improvement, where the need is indicated, are forwarded to the respective members. The work so far done has proved very successful in bringing up the product of the various members of the association to a high average quality. Having accomplished this result, the association is now continuing these daily tests and analyses for the purpose of grading the product of each member.

When a member's product has daily met the requirements of the prescribed standard for a period of three months, a "certificate of quality" is issued to that member, who may then designate his output as "certified malleable castings." These certificates are renewed quarterly when the quality required is maintained. A booklet published by the association on malleable iron and its production, gives some interesting information relating to the methods employed in the improvement of malleable iron castings. This booklet is distributed without charge by the association.

* * *

SOCIETY OF MECHANICAL INSPECTORS TO CONFER HONORARY MEMBERSHIP ON C. E. JOHANSSON

At a meeting to be held in the Engineering Societies' Building, Thursday evening, October 23, at 8 P. M., honorary membership will be conferred by the American Society of Mechanical Inspectors upon C. E. Johansson, the well-known originator of the gage standards, or blocks, identified with his name. As mentioned in the September number of MACHINERY, Mr. Johansson is in the United States for a few months in connection with some new devices and measuring instruments which he is introducing in the American market, and also to supervise the installation of his methods in the new American factory which will be operated by C. E. Johansson, Inc., at Poughkeepsie, N. Y.

POSTAL ZONE LAW A MENACE TO THE NATION

By Congressman FRANK W. MONDELL, of Montana, Floor Leader of the Majority Party in Congress

I am opposed to the zone system for the dissemination of news, ideas, and information because I am of the opinion that the establishment and maintenance of such a policy would, in the long run, have a most unfortunate, harmful and regrettable effect upon the American people.

Those whose views or arguments for the zone system are based primarily or largely on its effect, or alleged effect, on postal revenues, or the profits of the publishing business, fail utterly to grasp or realize the larger and infinitely more important aspects of postal systems as they affect the national life. If it be a fact that the flat postal rate on newspapers and magazines has been unduly low, that is a matter for consideration by the Post Office Committee, having in view the traditional policy of the American people. The fact that some people have been able to make a considerable amount of money in the newspaper and magazine business is, of course, one of the matters that a committee would consider in this connection, but it is by no means conclusive that a policy is wrong because some people have been able to make money under it—many having the same opportunities and privileges failed utterly.

The demand for the establishment and maintenance of a zone system is particularly lame and illogical when it is made by those who are urging a flat rate of one cent on letters. Such people to be logical should insist upon a zone rate for letters as well as papers and periodicals. Neither is the argument for a zone system strengthened by exaggerated statements of losses to the postal revenues under a flat rate. Undoubtedly the former flat rate did not wholly reimburse the postal revenues, but the most superficial examination of the matter renders ridiculous exaggerated statements of alleged losses. To the argument that publications enjoying the second-class rates are devoted more or less to advertisement, I offer the suggestion that a national dissemination of attractive advertisements is not without its educational benefits.

I have neither urged nor considered this as a party question. I urged this repeal before the previous Democratic Congress, as I shall before the present Republican Congress —not on party or partisan grounds, but on the broad platform that such a policy tends to circumscribe and provincialize our national life.

* * *

JAMES WATT CENTENNIAL COMMEMORATION

A Centenary Commemoration of James Watt, who died in 1819, was held in Birmingham, England, September 16, 17, and 18. Memorial services were held, and lectures were given dealing with the history and development of the application of science to industry, with particular application to steam engines. Visits were also made to the Soho Foundry, where some of the original buildings erected by Boulton and Watt are still to be seen, as well as to Ocker Hill, six miles from Birmingham, where an engine erected by Watt in 1776 is still in existence. This engine was regularly working until 1892, and was re-erected in its present position in 1898. The engine was working under steam during the commemoration exercises. Another engine built by Boulton and Watt is still located in the building in which it was erected, at Bordesley, about a mile from the center of Birmingham. This engine was also viewed by the visitors. It is proposed to commemorate the centenary by endowing a professorship of engineering, to be known as the James Watt Chair, at the University of Birmingham, and also to erect a James Watt Memorial Building, to serve as a museum for the remains of the work of James Watt and his contemporaries, Boulton and Murdoch. This building would also serve as a meeting place and library for scientific and technical societies in Birmingham.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

The New Tool Descriptions in MACHINERY are restricted to the special field the journal covers—machine tools and accessories and other machine shop equipment. The editorial policy is to describe the machine or accessory so as to give the technical reader a definite idea of the design, construction, and function of the machine, of the mechanical principles involved, and of its application.

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LeBlond Multi-Cut Lathe

The term "multi-cut" is applied to this new LeBlond semi-automatic lathe, owing to the fact that a number of tools are in operation simultaneously. This machine affords a convenient means for the performance of turning and facing operations, and it is possible for one operator to run several machines, so that the labor cost per piece can be held within very satisfactory limits. Two sizes of machines are built, which are designated as Nos. 6 and 9. The smaller size swings 6 inches and has a capacity for holding work up to 10 inches in length between centers, while the larger size swings 9 inches and will take work up to 16 inches in length between centers. Three different styles of headstocks are built for the No. 6 machine, and four different heads are made for the No. 9 machine. Either of these heads may be supplied according to the special requirements of the user.

THE R. K. LeBlond Machine Tool Co., Cincinnati, Ohio, is now building a "multi-cut" semi-automatic lathe on which one or more facing and turning operations can be performed simultaneously, one operator running several machines. It can be supplied with a variety of drives and equipment, adapting it for use in any industry having duplicate work of this character to perform. The work may be held on centers, arbors, or expansion or closer chucks of either the pneumatic or hand-operated type. On work that has been previously bored, reamed, and rough-turned on the turret lathe or automatic, and has to be finish-turned and faced, the multi-cut lathe finds its legitimate field. Gear blanks, cone pulleys, bevel gear blanks, pistons, steering knuckles, camshafts, transmission shafts, electric starter details, etc., are typical examples of work that may be rapidly machined.

As signified by the name "multi-cut," a number of tools are in operation at once, but these tools are all of the lathe tool type, and they are simple and inexpensive. For this reason comparatively small lots of work may be profitably run. The machine is easily and quickly set up. It is not a lazy man's lathe, but the mental and physical effort that is required to obtain a predetermined rate of production is reduced to an absolute minimum. The multi-cut is essentially a lathe. It partakes of all the characteristics of a lathe and uses lathe tools of the simplest type. It fits into a lathe department without disturbing present standards of equipment or schedules.

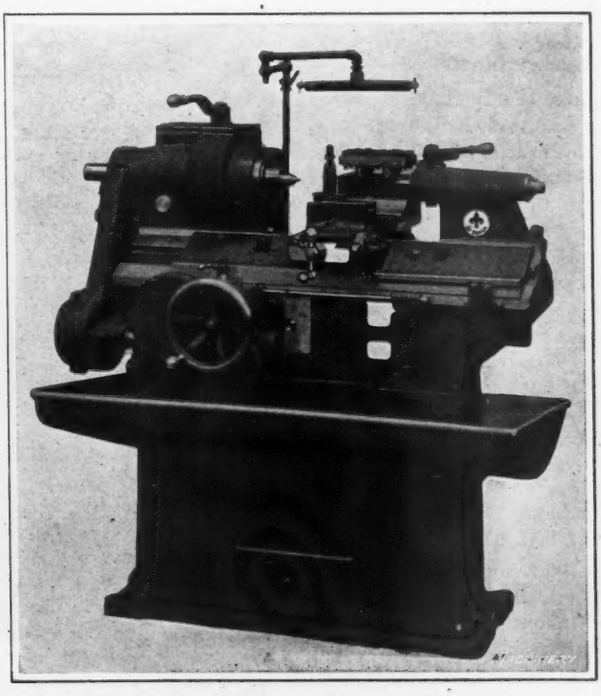


Fig. 1. LeBlond No. 6 Multi-cut Lathe equipped with a Style C Adjustable-speed Geared Headstock, Plain Facing Attachment, Quick-acting Tailstock, and Plain Turning Slide

The multi-cut lathe is producing most efficiently when one attendant is operating two machines. The automatic operation of the turning and facing slides, and automatic trips at the end of their travel make this readily possible, the operator loading extra arbors or mandrels while the cut is in progress. Turning and facing cuts are completed simultaneously, the two sides being so timed as to finish their respective cuts together. Various combinations of relative movement between the turning and facing slides may be obtained, a simple system of change-gears, reading direct from the work diagram, controling this relationship. Due to the simple set-up and the inexpensive forms of tools that are used, small lots of work can be profitably run.

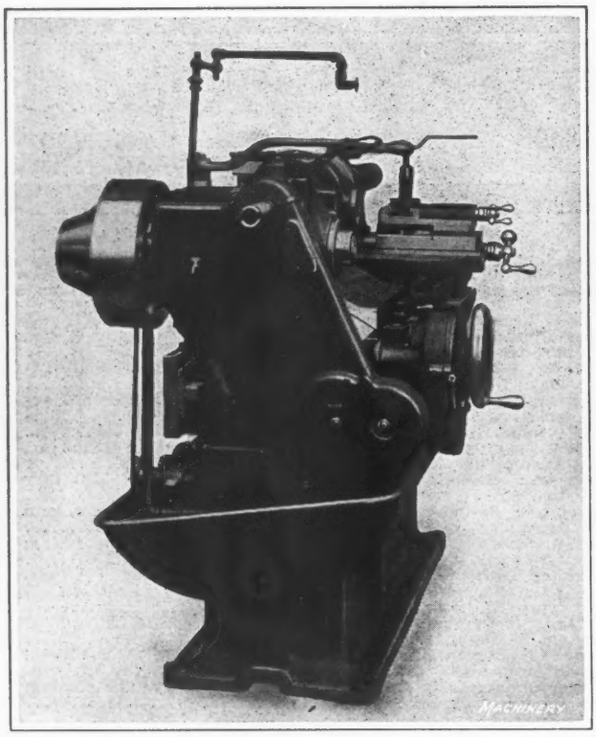


Fig. 2. Head-end View of Multi-cut Lathe with Right-angle Drive, showing Pump Drive and Draw-off Valve for Reservoir in Headstock

Selective Equipment

The multi-cut lathe is built in two sizes, namely, a No. 6 with a swing of 6 inches and 10 inches capacity between centers; and a No. 9 with a swing of 9 inches and 16 inches capacity between centers. The No. 6 size is built with three types of headstocks known as Styles A, C, and D; and the No. 9 with four types of headstocks, namely, A, B, C, and D. Either size can be furnished with a screw or quick-lever-acting tailstock, plain or universal angular facing attachment, taper attachment, compound rest, draw-in or closer chuck and collets. The No. 6 machine shown in Fig. 1 has a Style C head, and Styles A, B, and D heads are shown in Fig. 7. Owing to the varied class of industries to which the multi-cut lathe is adapted, this equipment is made selective, enabling the consignee to readily select the combinations best suited to his requirements.

Features of the Different Styles of Headstocks

The Style A headstock is a single-speed, plain back-geared headstock with self-oiling bronze bushings, ball-thrust bearing spindle, and double helical or herringbone back-gears. The spindle bearings are renewable bronze boxes, babbitt lined. A friction countershaft with an automatically operating brake is supplied as a regular equipment. This headstock is best adapted to work on cast-iron or steel parts, requiring fairly heavy reductions and no speed changes, for duplicate work in quantities and where the machines are placed in parallel lines in a regular lathe department and driven from a countershaft. The countershaft is provided with a split pulley to facilitate making speed changes when required.

The Style B headstock is a six-speed selective-geared, right-angle driven equipment. Three instantaneous changes are obtained with one lever, and a shifter knob compounds these changes through a back-gear to give six speeds. The gears are of 3½ per cent nickel-chrome steel, heat-treated and hardened. The headstock is oil-tight, and the gears and friction clutches run in a bath of oil. The spindle bearings and driving clutch are also continuously flooded with oil from this same supply. The main friction clutch is mounted in the driving pulley, where it is operating at a constant high rate of speed and subject to little strain. It is of the multiple-disk type, running in oil, with a brake operating from the clutch handle. The driving pulley shaft is located at 90 degrees to the spindle to permit of a more compact grouping of the machines. The spindle is fitted with tapered bronze boxes which are babbitt lined and provided with convenient means of adjustment for wear. The thrust is taken against ball-thrust bearings.

The Style C headstock is a fixed-speed head, applicable for quantity duplicate production. The speed may be adjusted to suit conditions by means of change-gears regularly furnished to provide three changes. A four to one back-gear is incorporated in the drive, the changes being made by simple slip-gears in the end of the head. The driving clutch, brake, spindle bearings, etc., are identical with the Style B head, and the same system of flooded lubrication for gears, bearing, and clutch is also employed. The head is provided with a right-angle drive and is intended to be driven direct from the lineshaft. When this is not feasible, a jack-shaft can be supplied at an extra cost.

The Style D headstock is a single-speed, open-belt head, provided with a lever-operated, friction starting and stopping mechanism and brake. The driving pulley is excessively large, and it is accurately balanced, permitting the application of speeds to 1000 revolutions per minute and adapting this headstock to working on brass, bronze, aluminum, and free cutting steels of medium diameters, on which very high cutting speeds may be maintained. The friction clutch is mounted in the periphery of the driving pulley and it is of the double finger wedge acting type, being adjustable for tension, and accurately balanced against all rotative forces. A brake is mounted on the spindle, bringing it to an instant stop when the clutch is released, a spring tension being provided in order to prevent accidental starting. The spindle bearings are made of bronze, babbitt lined and provided with sight-feed oilers; and the thrust is absorbed against ball-thrust bearings. This head is intended to be driven from the lineshaft, but a jack-shaft with a split pulley can be supplied if it is required.

Taper Attachment

The taper attachment consists of a rigid bracket bolted to the bed, which carries an adjustable taper guide bar and a

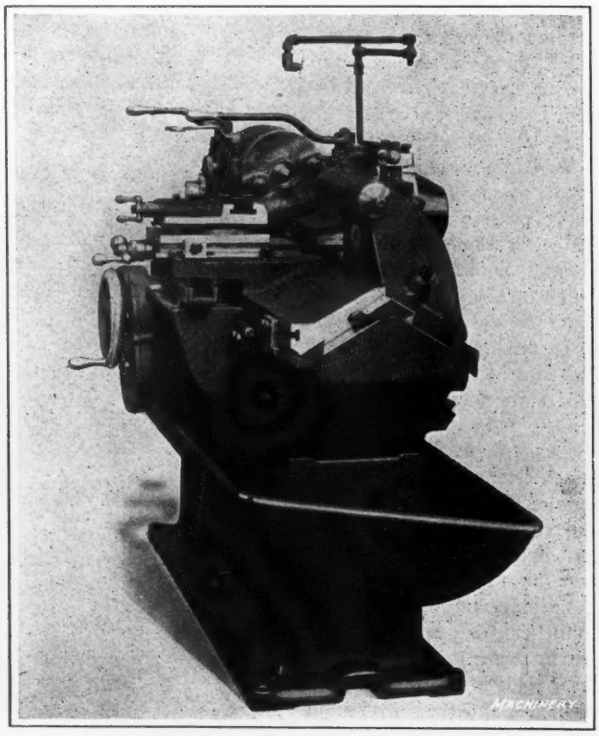


Fig. 3. Tail-end View of Multi-cut Lathe showing Taper Attachment, Right-angle Drive, and Equalizing Type of Faceplate

sliding shoe engaging the guide bar. This sliding shoe is attached to the cross-slide imparting to it an "in" or "out" movement with relation to the angular setting of the guide bar. The guide bar may be set from straight up to 4½ inches of taper per foot, on either side of center, and it is clamped in the selected position by two T-slot bolts. The taper guide bar and sliding shoe may be replaced by a form plate and roller for the automatic duplication of irregular shapes.

Plain and Universal Facing Attachments

The plain facing attachment faces diameters up to the full swing of the lathe, at right angles to the turning center. The feed of the facing slide is obtained entirely by the relative movements of flat and dovetailed slides which are accurately gibbed and made adjustable to compensate for wear. The facing rest is fed toward the center of the lathe on a broad square-lock slide, to which it is properly gibbed, and the cross-facing slide is movable along the bed and rigidly clamped to the shears in any desired position. The facing bar slide carries the swivel guide bar which is fed along the bed at varying rates of speed.

A sliding shoe carried on the facing attachment slide engages the swivel guide bar which may be set at any angle within its range, imparting a vertical motion to the shoe, which is transmitted through a rack and hardened pinion to the cross-slide. By changing the angularity of the swivel guide bar, the feed of the cross-slide is varied or timed to complete its work at the same time as the turning slide, or it may be accelerated to finish ahead of the turning slide to permit of overlapping on forming and turning tools, or vice versa. The feeds to both the turning and facing slides are tripped by the same clutch and will duplicate dimensions within close limits of accuracy. The standard tool-block furnished on these machines, is arranged for multiple tools which can be held parallel or at any angle, by reason of the spacing of the binder screws. The tool-block is adjustable to the center of the lathe and firmly clamped in position by two heavy bolts.

As its name indicates, the universal facing attachment is adapted for angular facing operations on bevel bear blanks and similar shaped pieces. When the facing attachment is used in connection with a taper turning attachment, the back and face angles of a bevel gear blank can be turned simultaneously.

The swivel block is accurately graduated to facilitate angular settings and clamped firmly in the selected position by two heavy T-slot bolts in a circular T-slot. The feed is through a pair of hardened generated miter gears to the feed-rack. Aside from this swivel feature, the universal attachment and tool-blocks are identical with the plain attachment.

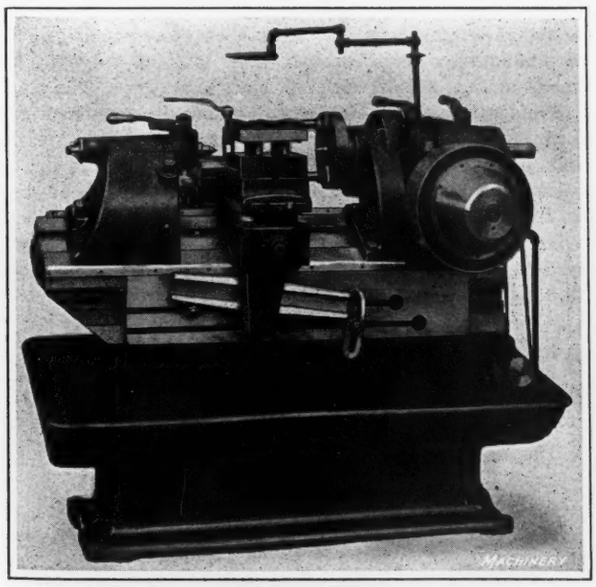


Fig. 4. Rear View of No. 9 Multi-cut Lathe showing Right-angle Drive, Universal Facing Attachment, and Quick-acting Tailstock. This Illustration shows how the Feed to the Facing Attachment is transmitted through Flat and Dovetailed Slides, the Taper Guide Bar being set at Different Angles to vary the Feed of the Facing Attachment with Relation to the Travel of the Turning Slide

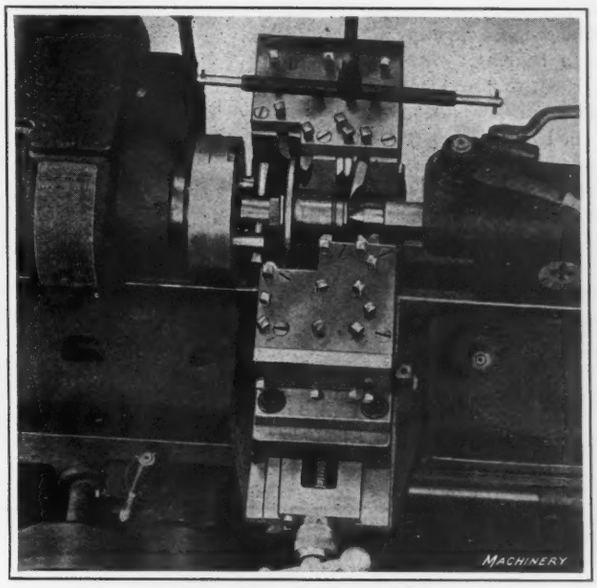


Fig. 5. Tooling of No. 9 Multi-cut Lathe for simultaneously turning and facing an Automobile Wheel Hub. Nine Cutting Tools are working simultaneously on this Job

Feed for the Turning and Facing Slides

Variations in feed for the turning and facing slides are obtained by loose change-gears applied to the feed bracket and worm box. These feeds read to 0.001 inch per revolution of spindle, and a simple direct-reading work diagram is sent with each machine to show the available change-gear combinations and the resulting feeds. The feeds of the front slide are fixed by the change-gears that are used, while the feeds of the facing slide may be further varied with relation to the feed of the turning slide by the angularity given the swivel guide bar, resulting in a practically unlimited combination of feed relations. When the machine is performing forming operations or making heavy reductions with the facing slide, it is sometimes desirable to accelerate or decelerate the rate of feed as the tool approaches the center, and this is done by replacing the swivel guide bar with a former bar and roller that are designed to suit the specific job being done.

The feed worm and wheel are mounted on fixed centers and encased in an oil-tight gear-box bolted to the bed. The feeds are tripped by a sensitive jaw clutch engaging a similar clutch mounted on the worm-wheel. The feed drive is then through changeable gears and a pinion and bull wheel to the rack on the carriage. The drive to the facing slide is transmitted by similar change-gears through the bed to the feed-rack on the facing attachment slide, on which the swivel guide bar is mounted. The feed-rack for both the carriage and facing attachment is placed in the center of the slides, imparting a smooth unrestricted feed, without any binding action. The handwheel at the front of the worm box furnishes a means of quickly returning the turning and facing slides to the starting position after the completion of each cut. The worm-wheel and clutch are running continuously in oil, and the thrust of the worm is taken against ball-thrust bearings. All of the gears that are subject to the greatest strains are made of nickel steel, heat-treated and hardened.

Features of the Bed and Carriage Design

The bed is of a special anvil section, with broad slides for the carriage and bearings for the headstock and tailstock, so disposed that the pressure resulting from the cut

tends to force the slides more firmly to a bearing. The slides are provided with narrow dovetailed guiding shears, which are taper gibbed to prevent any tendency of lifting from the bearing. The bed is provided with internal ribs and mounted on a cabinet base, in which the pan and chamber for cutting compound are cast. The pan becomes an integral part of the bed, and greatly stiffens the entire machine. The pan is provided with a strainer that separates the chips from the cutting compound, which flows back to the base of the machine. A geared rotary pump and piping for circulating the compound are supplied as regular equipment. A cover plate is provided for cleaning out the base.

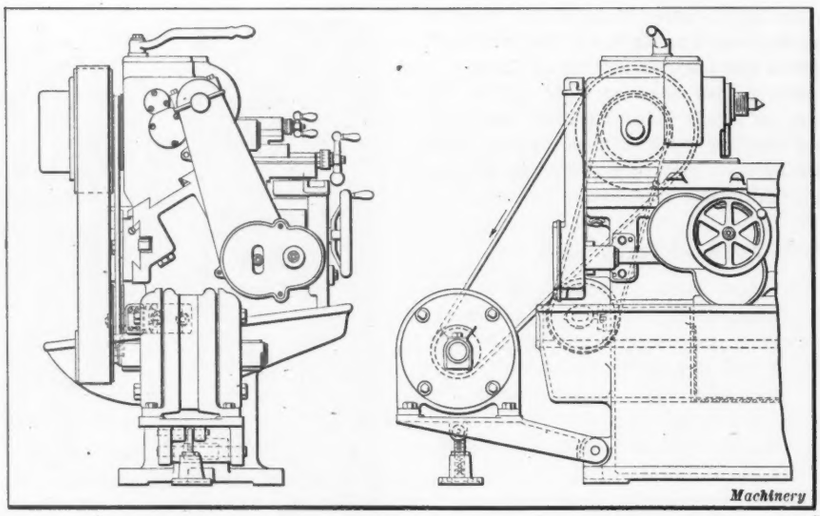


Fig. 6. Arrangement of Individual Electric Motor Drive on the LeBlond Multi-cut Lathe

The carriage has a broad slide extending practically the full length of the bed and it is scraped to a bearing for its entire length. It is provided with double tapered gibs with fine thread adjustment. The cross-slide for mounting the compound or the plain rest is cast integral with the carriage. The fact that the headstock and tailstock are located and carried by the rear shear permits the carriage to travel past them and keep the slides continuously covered. The long carriage bearing is one of the largest contributing factors to the general rigidity of the multi-cut lathe, permitting the use of gang tools, forming slides, etc., without any tendency for the carriage to climb or bind on the shears. The feed-rack is set exactly in the center of the carriage slide, resulting in a smooth and unrestricted feed.

Special Tool Equipment and Drivers

The R. K. LeBlond Machine Tool Co. is prepared to offer engineering service for the lay-out and recommendation of tool equipment, methods of chucking, etc. They will supply time estimates, design and build tools for a guaranteed output, and furnish demonstrators. The spindles on all multi-cut lathes are regularly extended for the application of air chucks, special expansion mandrels, closer chucks, etc.

Draw-in Attachment and Collets

A lever-operating draw-in attachment, closer, and full set of collets is supplied when required. These collets are made in sets and furnished as follows: For the No. 6 multi-cut lathe, 11 collets of ¼-, 5/16-, ⅜-, 7/16-, ½-, 9/16-, ⅝-, 11/16-, ¾-, 13/16-, and ⅞-inch capacity. For the No. 9 multi-cut lathe, 13 collets of ¼-, 5/16-, ⅜-, 7/16-, ½-, 9/16-, ⅝-, 11/16-, 3/4-, 13/16-, 7/8-, 15/16-, and 1-inch capacity.

Plain and Compound Rests

A plain block rest mounted on the cross-slide is regularly furnished, equipped with a single-screw type tool-post and an adjustable positive cross-stop. A substantial compound rest can be supplied when conditions require it. The swivel is of large diameter and graduated in degrees for angular turning or taper boring. Adjustable taper gibs are provided to compensate for wear on the slides. The T-slot bolts are large in diameter and are placed in a circular T-slot, enabling the top and swivel slides to be firmly clamped after setting.

Lever-operated Quick-acting Tailstock

A quick lever-acting tailstock is provided to permit of the quick removal and replacing of work with a single movement of the operating handle. The center is brought into contact with the work at any desired pressure by a conveniently placed lever, and further movement of the same lever locks the tailstock barrel and clamps the spindle.

Individual Electric Motor Drive

Either the Style B or C headstocks may be motor driven, as shown in Fig. 6. The motor is attached to a motor plate hinged from the cabinet base of the machine and provided with an adjustable jack for maintaining the desired belt tension. A constant-speed alternating- or direct-current motor, running preferably at 1200 revolutions per minute is recommended. It should develop 3 horsepower for the No. 6 multi-cut lathe and 5 horsepower for the No. 9 machine.

JOHANSSON ANGLE GAGES AND MEASURING TOOLS

A set of angle gages and a number of other measuring tools and devices have recently been brought out by C. E. Johansson, Inc., 245 W. 55th St., New York City. The angle gages, made in a set of eighty-five blocks, as shown in Fig. 1, are similar to the well-known Johansson standard measuring blocks in that they are made in sets and that the angles required are obtained by combinations of blocks. In this case, however, any combination for which the angle-blocks are intended is obtained by the combination of two blocks only. In the case of smaller angles, each block is provided with four different angles, one at each corner; but in the

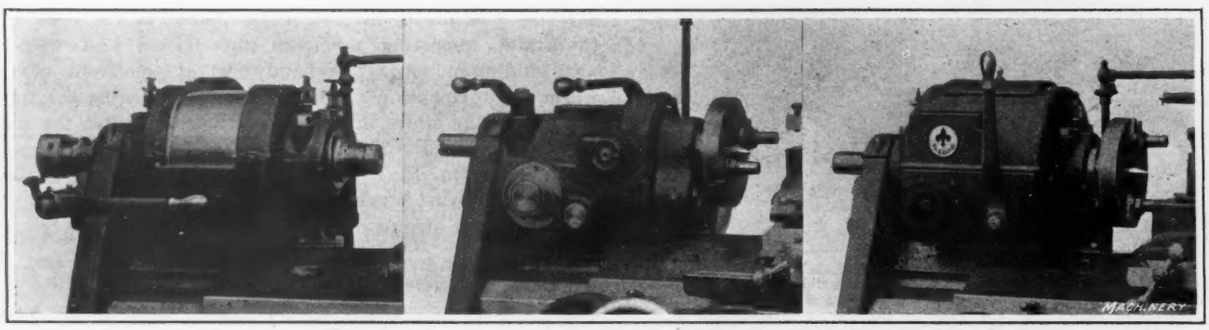


Fig. 7. Style A Single-speed Headstock with Single Driving Pulley and Plain Back-gears, and a Lever-operated Draw-in Collet Chuck; Style B Selective-speed Headstock with a Multi-disk Clutch and Equalizing Faceplate Drive; and Style D Single-speed Open-belt Headstock with a Lever-operated Friction Starting and Stopping Mechanism and Brake

Fig. 1. Set of Angle Gages by Means of which Combination Gages may be obtained for Every Minute up to 180 degrees

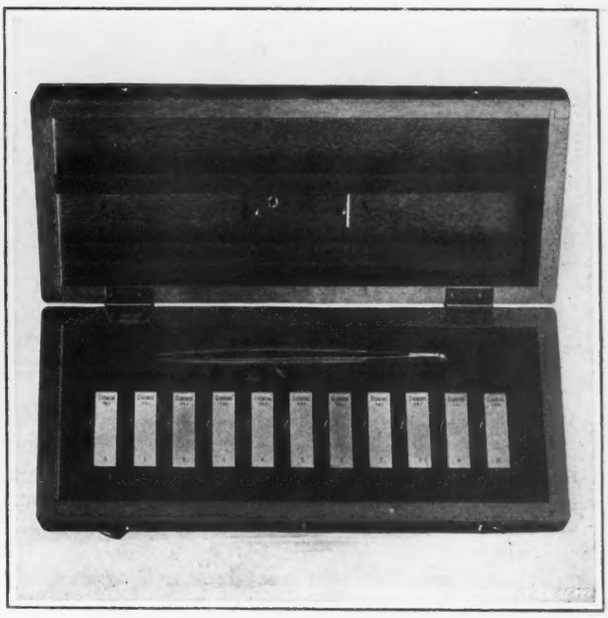


Fig. 2. Set of Gage-blocks in which Consecutive Blocks differ One-millionth Inch in Size from each other

case of larger angles, each block has but two angular measurements, one at each end. The set is so arranged that by the use of the eighty-five blocks it is possible to obtain, by minutes, every angle from 0 degree to 180 degrees; in other words, by these eighty-five blocks, it is possible to make, by combinations of two blocks, 10,800 angle gages.

The object of such a set is to save the making of a great number of individual angle gages in shops where angular measurements by means of gages need to be made, either at the bench or in the inspection department. It is stated that in the making of these gages the same care to insure accuracy is taken as in the making of the standard Johansson blocks. As seen in the illustration, a holder is provided, similar to the holder used for the standard gage-blocks, in which the gages may be assembled in order to obtain the required angle.

Fig. 2 shows a set of eleven blocks similar to the standard Johansson gage-blocks, except that, in this case, the accuracy is far greater than that required in the regular commercial blocks. In this case, each block differs from the next succeeding one by one-millionth of an inch, and it is stated that each block is accurate within plus or minus one-ten-millionth of an inch. This gage set is not intended for commercial use, because it is recognized that there is at present no commercial need for so accurate a set of gage-blocks. It is intended for scientific use where extremely accurate measurements or comparisons are to be made. Possibly in the future, even commercial manufacture will require standards of greater accuracy than those provided by the present standard gage-blocks, but, as yet, there seems to be no demand for commercial purposes for blocks of such extreme accuracy. As a scientific instrument, however, this gage set is of great interest.

Fig. 5 shows a combination micrometer consisting of two arms, a micrometer head, a holder of the standard type used for the Johansson measuring blocks, and a number of standard length blocks by means of which the range of the micrometer may be varied according to the requirements. The micrometer head is permanently assembled in one arm. This micrometer is made with three holders having capacities, respectively, up to 4, 8, and 12 inches; but the 4-inch micrometer may be made into a 1-, 2-, 3-, or 4-inch micrometer, according to whether one or more blocks of standard size are used in the holder between the two arms; the 8- and 12-inch sizes may be similarly modified. The object of this combination micrometer is to provide a means whereby any diameter or length may be measured with but one micrometer head, by substituting different gage-blocks between the arms, according to the size of the work to be measured. Another advantage claimed is that the arms are adjustable with regard to the holder, and the micrometer head may be extended out from the holder as shown in the illustration, or may be moved quite close to the holder, according to the character of the work to be measured. It is evident that for work that permits the head to be moved quite close to the holder, a very rigid tool will result; but even when the

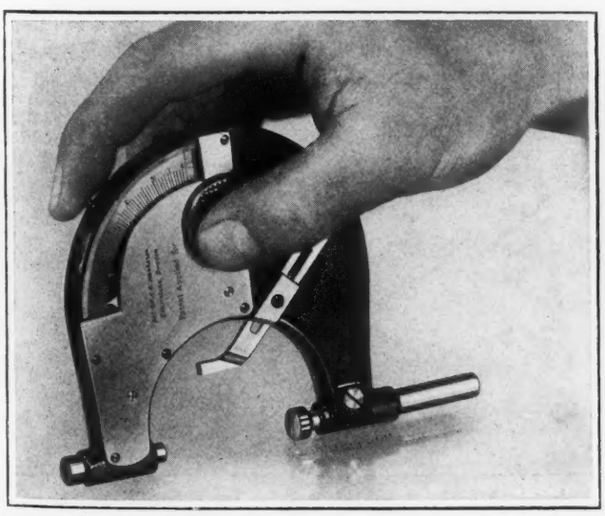


Fig. 3. Tolerance Indicator

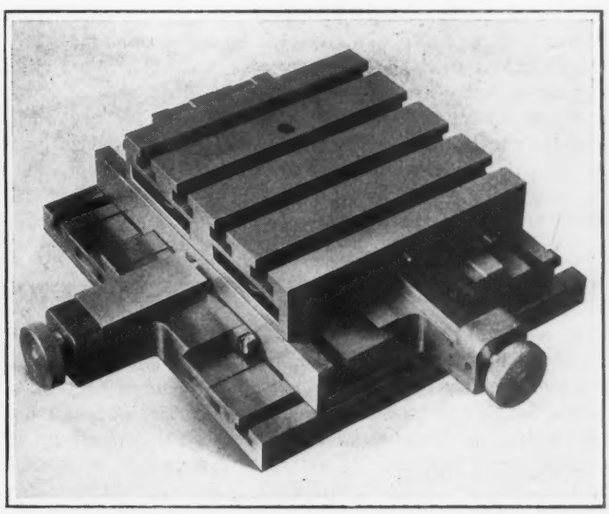


Fig. 4. Compound Slide for Accurate Spacing of Holes

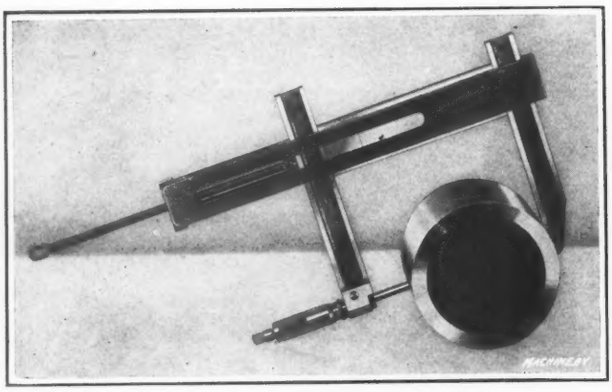


Fig. 5. Combination Micrometer

head extends quite a distance from the holder, as shown in the illustration, the rigidity of the straight arms is very great, and by making the arms of heavy section, as indicated, any tendency to spring may be obviated to a greater degree, it is claimed, than with micrometers with a bent frame.

Fig. 3 shows an instrument known as a "tolerance indicator" which presents several novel features. The object of the instrument is to indicate whether work measured is between certain predetermined limits. The anvil to the right is adjustable and set to suit the work to be measured. The anvil to the left is movable and connected with the indicating pointer. The sliding part at the top of the semicircular opening in the tool is adjustable to the diameter of the work, and acts as a stop, so that when the work is measured, the gage will be pushed over the work to just the correct point. The particularly novel feature of the instrument is that the pointer will become locked at whatever position to which it is moved by the movement of the movable left-hand anvil. It will remain locked in this position until the small knob at the outside of the frame or casing is depressed by the end of the finger, as shown, when it will snap back to the zero position. By this locking arrangement, it is possible to retain the reading of the instrument after the instrument has been removed from the work being measured; hence, work can be measured in dark or inaccessible places, and the instrument removed to a light place and the reading taken. The scale reads to 0.0001 inch. The tolerance indicator is provided with holders for the finger grip similar to those used on the regular Johansson limit gages, thereby insulating the heat of the hand from the instrument.

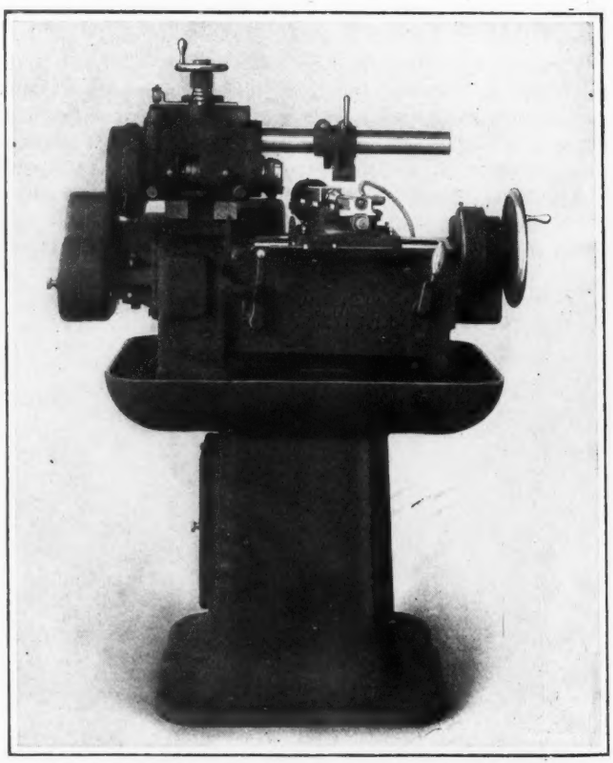
Fig. 4 shows a compound slide intended for the drilling or boring of accurately located holes. As shown, it consists of two slides actuated at right angles to each other. These slides may be set by the use of standard gage-blocks, as indicated, and in that way their position relative to each other may be very accurately determined. Then if a hole is bored or drilled in the position determined by the gage-blocks, another hole may be bored or drilled very accurately, with relation to the first hole, by simply changing the gage-blocks as required, so as to move the slides a definite amount in two directions to the location for the next hole. This slide may be mounted on any machine table, and should prove especially useful in the making of drill jigs or similar work, as well as in the drilling of holes accurately located without the use of jigs, as, for example, when only one or a few pieces of the same kind are being made of work which requires accurately spaced holes.

BARBER-COLMAN NO. 2 GEAR-HOBBING MACHINE

A small hobbing machine which is designated as a No. 2 size, has recently been added to the line of machinery built by the Barber-Colman Co., Rockford, Ill. The bed and upright of this machine are of heavy box section and are made as an integral casting. A box section design is also used for the sub-base, which contains a large oil reservoir for supplying oil or cutting compound to the hob and work. It will be seen that the machine has a horizontal work-slide, and there is provision for allowing shafts to project through the spindle. The work can be conveniently handled and clamped close to the spindle bearing. The spindle is machined from a crucible steel forging and accurately finished to size by grinding. A conical bearing supports the spindle at the front end, while the rear bearing is straight. Both of these bearings run in long bronze bushings, with provision for taking up wear by means of a hardened and ground steel thrust washer at the front and a pair of ground locknuts at the back of the tapered bushing. The hole through the spindle is 29/32 inch in diameter, this hole being enlarged to a No. 9 B. & S. taper at the front end to receive the special work-holding arbors which are securely held in position by means of a draw-in bolt.

The work-spindle slide is accurately adjusted to position by means of an elevating screw provided with a micrometer dial reading to 0.001 inch. Gear blanks that are to be hobbed on this machine are usually held on an arbor fitting in the No. 9 B. & S. taper socket of the work-spindle and rigidly supported at the outer end by means of an overhanging bracket. An overhanging steel arm carries the bracket which is provided with a quick-acting clamp handle, so that it can be quickly released and swung out of the way when the work-holding arbor is being loaded. A dowel-pin in this bracket, which fits into a locator attached to the overhanging arm, provides means of relocating it in exact alignment with the work-spindle after the work has been set up. Indexing of the work-spindle is accomplished by a hardened and ground worm and bronze worm-wheel. The case containing this index mechanism is attached to the work-slide and is completely enclosed to provide a continuous bath of oil.

To obtain the desired physical properties for the hob spindle, this member is machined from steel, after which it is hardened and finally finished to size by grinding. This spindle has a conical front bearing, supported by a bronze box, with means of compensation for wear; and both of the hob spindle bearings are mounted in a steel slide which affords a convenient means of moving the hob endwise. The design of the hob swivel and slide locates the hob close to the ways of the machine, and affords a high degree of rigidity. The swivel is in a horizontal position, which enables it to be readily set to the proper angle. A vernier reading



No. 2 Gear-hobbing Machine built by the Barber-Colman Co.

to ten minutes is provided on the swivel to facilitate accurate setting. Long guide ways are provided for the swivel slide, with gibs to afford means of taking up wear.

Depending upon the customers' requirements, the machine may be fitted with either a right-hand or a left-hand hob swivel, the former accommodating a range of spiral settings from 60 degrees right-hand to 90 degrees left-hand, while the latter accommodates a range of spiral settings from 60 degrees left-hand to 90-degrees right-hand. A right-hand swivel is furnished unless instructions are given to the contrary. An automatic belt-shifter is provided for stopping the machine after the hob has finished its work. Provision is made for quickly setting the hob swivel slide by means of a hand-wheel geared to the lead-screw. A chain-driven geared pump, with a capacity of four gallons per minute, is furnished as a regular equipment, and it is permanently attached to the machine. The coolant is strained through a chip pan and then discharged into the sub-base. Guards which completely enclose the pulleys and gears are also regular equipment.

Speed changes of the hob are secured by transposing gears in a gear-box at the end of the machine. Under average conditions, sufficient change-gears are provided to meet the requirements of high-speed steel hobs. Both the index and feed trains are positively driven, and they are varied by gear combinations in the index change-gear box at one end of the machine and in the feed change-gear box at the other end of the machine. This hobbing machine is of the constant-speed type and may be driven directly from a line-shaft or by a motor. The driving pulley is 6 inches in diameter and it is driven at a speed of 800 revolutions per minute by a 1½-inch belt. Special work-spindles can be supplied to hold work by means of spring collets or floating chucks. If so desired, this machine can be supplied with a cast-iron pan for a sub-base, which makes an ideal arrangement for a bench type of machine.

DAVIS-BOURNONVILLE NO. 2 CAMOGRAPH

For use in boiler shops and fabricating plants, to provide a means of automatically cutting hand-holes and other openings in boiler sheets, ship plates, tanks, drums, etc., with an oxy-acetylene torch, the Davis-Bournonville Co., Jersey City, N. J., has recently placed on the market a machine known as a No. 2 camograph. One of these machines is shown in Fig. 1, and Fig. 2 shows an example of a cut made by it. In this connection, attention is called to the fact that the latter illustration may be somewhat misleading. It will be apparent that a hole was punched in the metal to afford a starting point. This practice is quite generally followed, although it is not necessary to make a starting hole because the oxy-acetylene flame will soon penetrate the solid metal; but in actual practice where a starting hole is made, this hole would be placed within about an inch of the periphery of the hole to be cut, instead of at a point near the center of the hole, as shown in Fig. 2. The camograph works automatically and rapidly, the actual time of cutting a hand hole having a periphery of 12 or 13 inches in length in a ½-inch plate being about one minute. The width of kerf is only about 1/16 inch, and the cut edges are very smooth and true.

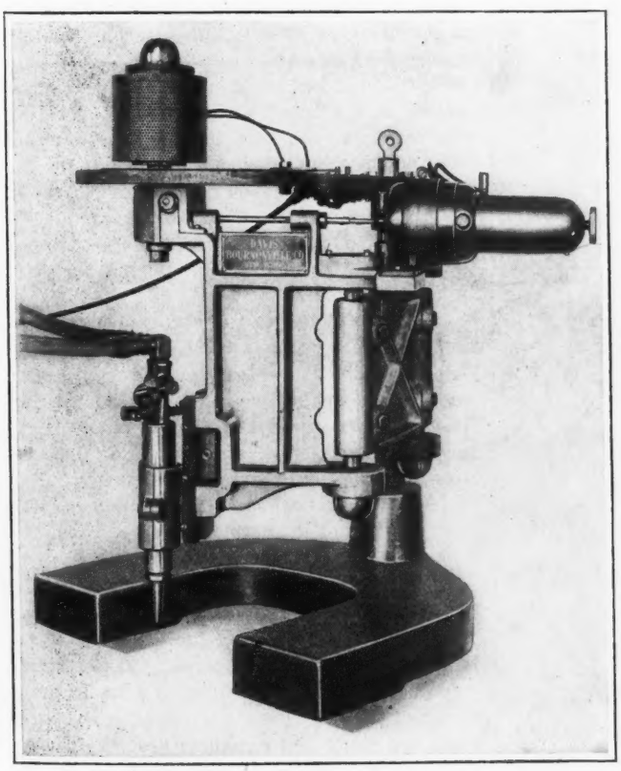


Fig. 1. No. 2 Camograph built by the Davis-Bournonville Co. for Cutting Holes in Plates

Fig. 2. Example of a Cutting Job done with the Camograph. Note the Smoothness of the Cut

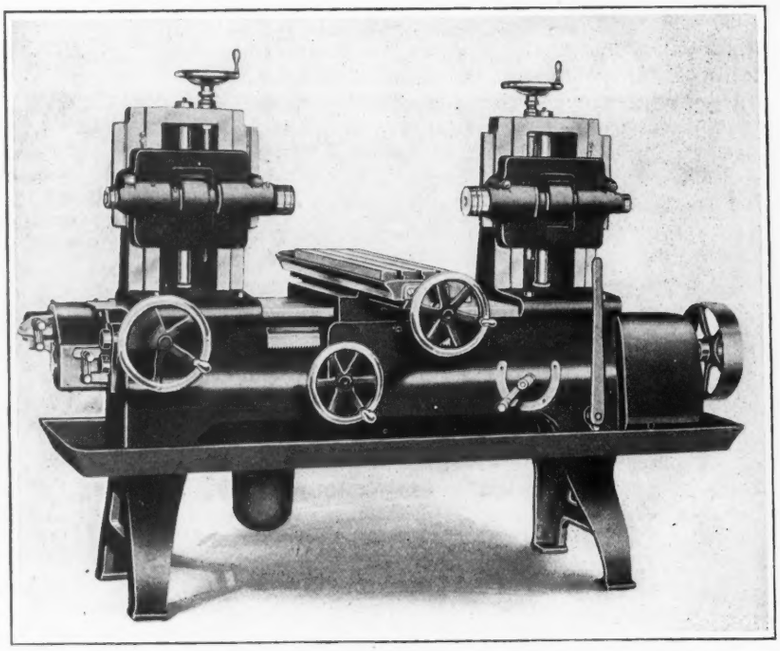
While in operation, the torch of the No. 2 camograph is mechanically traversed at a predetermined rate, thus insuring steadiness and smoothness of operation. Unlike the oxygraph machine of this company's manufacture, no tracing wheel is provided for following a paper drawing of the outline to be followed by the torch. This new machine is intended for repetition cutting, and the torch is made to follow a fixed path, the contour of which is governed by a metal form or cam. Provision may be made for cutting various shaped openings by substituting the proper cams on the machine. It will be seen from Fig. 1 that the machine consists of a base with a U-shaped opening through which the torch flame strikes the work.

At the back of the base there is a vertical post to which a double-jointed radial arm is pivoted. The cutting torch is mounted on the outer end of the radial arm which provides for movement in any direction from the entire area which can be covered by the machine. The jointed arm is made of two aluminum castings of light but rigid construction, which are mounted on ball bearings so that there is a minimum of frictional resistance. A feed roller on the outer or free end of the radial arm is surrounded by a yoke in which is mounted a guiding cam or templet which controls the movement of the torch. A unique principle of guidance is employed. The feed roller is magnetized by a powerful electromagnet, and is thus attracted to the inner face of the cam, the parts in contact being made poles of the magnet, one of which rotates and thus acts as a traction driver. A traverse movement or feed is provided by a small variable-speed electric motor mounted on the swinging radial arm.

The nominal diameter of the largest hole which can be cut with the No. 2 camograph is 7 inches, but openings other than circular, which have one dimension much larger than the other, may be easily cut. The machine has sufficient capacity for working on all thicknesses of plates that are used on the largest marine boilers. A double push-button switch provides a convenient means of starting and stopping the machine and of energizing the magnet.

W. B. KNIGHT DUPLEX MILLING MACHINE

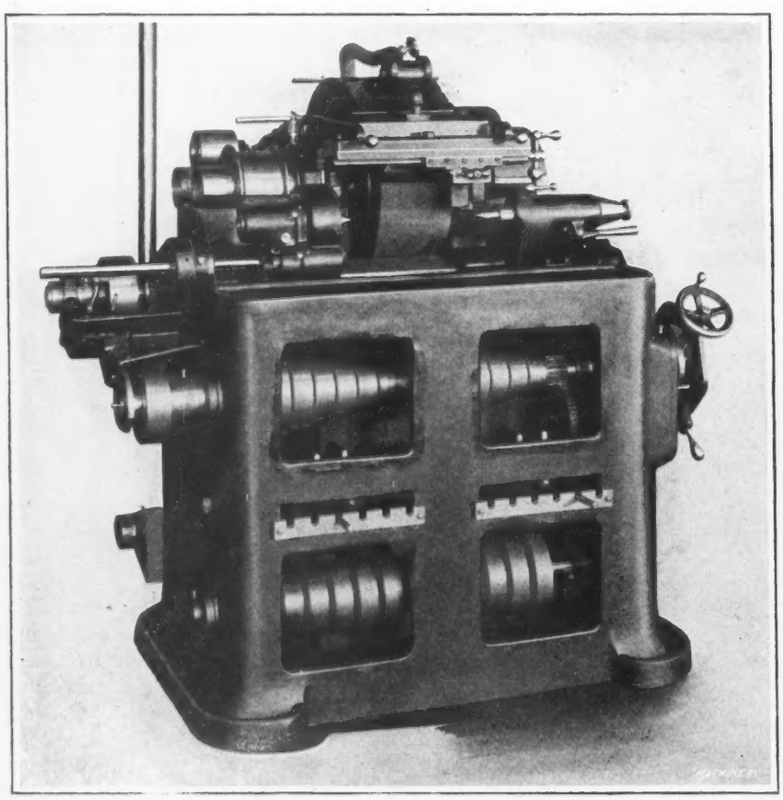
In the March, 1914, number of MACHINERY, a description was published of a duplex milling machine which had just been placed on the market at that time by the W. B. Knight Machinery Co., 3920 W. Pine St., St. Louis, Mo. Recently, this firm has developed another duplex miller which is of quite similar design to the one previously announced, except that it is of much heavier construction and of larger dimensions, and provided with a wider range of feed movements. These changes, together with improvements made in details of the design, adapt the machine for handling a wider range of work and heavier pieces than could be handled satisfactorily on the original Knight duplex miller.



Improved Type of Duplex Milling Machine built by the W. B. Knight Machinery Co.

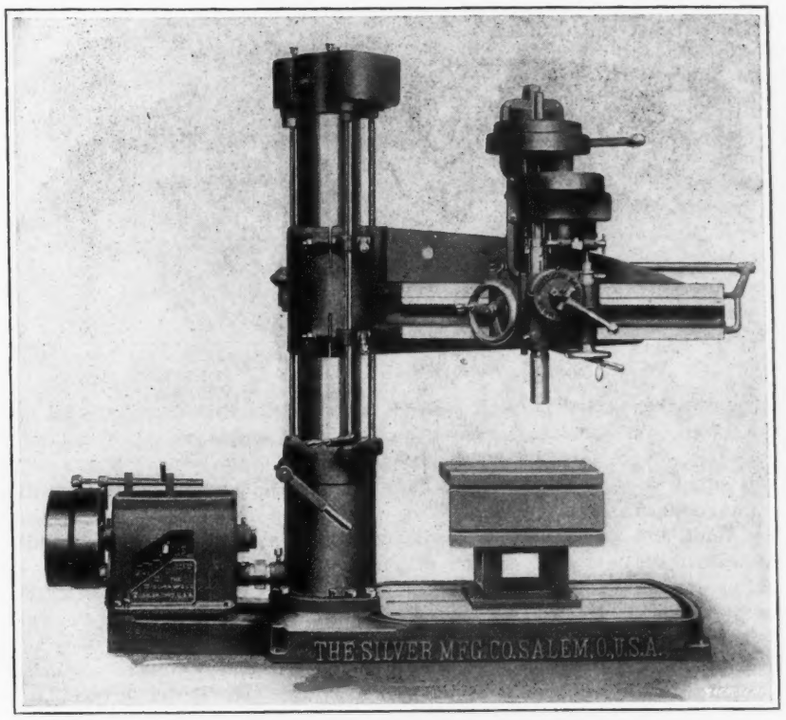
WOODS PLAIN GRINDING MACHINE

The Woods Engineering Co., Alliance, Ohio, is now building a plain grinding machine which is semi-automatic in its movements, the operator being merely required to set up and remove the work. This machine is styled a "wide-wheel automatic grinder." The work has a straight in and out movement, with a slight longitudinal movement during the grinding period. Grinding wheels may be used up to 20 inches in diameter by 8 inches face width, and the machine has a capacity for work up to 10 inches in diameter by 15 inches in length. In working out the design, a departure has been made from established practice in providing mechanism for obtaining the cross-feed movement, instead of the regular dovetail or V-slide. A rocking motion is provided. The headstock and tailstock are movably mounted on a square shaft which has journals at the ends that operate in bronze-bushed pedestal bearings. Clamped to this shaft there is an arm which carries the mechanism for making diameter adjustments in grinding. This arm is shown at the right-hand side of the machine, and near it there will be seen a handwheel which is the only one on the machine, so that it will be evident that manual labor is reduced to a minimum. A shaft running through the housing parallel with the square shaft carries a cam on the right-hand end that controls the movement of the arm connected to the square shaft, and governs the movement of the work to the grinding wheel. This camshaft has six speeds ranging from 3 revolutions per minute to 1/3 revolution per minute. One revolution of the cam completes the job. In operating the machine, the camshaft is kept running continuously, and acts as a pacemaker for the operator; but if necessary, the trip can be set to disengage the feed at the completion of each operation, or the feed can be tripped by the operator at any time during a revolution of the cam.



Plain Grinding Machine built by the Woods Engineering Co.

At the left-hand end of the camshaft there is a cam that controls the clutch pulley driving the work. These two cams are timed with each other, so that when the work moves up to the grinding wheel the clutch pulley is engaged and the work starts rotating just before it comes into contact with the grinding wheel. When the operating cycle has been completed and the work recedes from the wheel, it stops rotating and comes back into position for reloading. Six speeds for the work are obtained by a set of cone pulleys located inside the base of the machine. These pulleys are ordinarily enclosed, but the covers are shown removed to illustrate the arrangement of the mechanism. Changes of speed for both the work and camshaft are obtained by means of handles projecting through the front of the machine. The grinding wheel is



Radial Drilling Machine built in 2½-, 3- and 3½-foot Sizes by the Silver Mfg. Co.

mounted on a spindle between the bearings, and is driven by two 4-inch belts from a motor mounted on the base of the wheel-head. This head swivels on a central stud for grinding tapered work. The grinding wheels are carried on wheel centers, and in changing wheels it is not necessary to change the adjustments of the spindle bearings or to remove any pulleys. The wheel centers have a bore large enough to pass over all other parts of the spindle. A wheel-truing device is provided on the wheel guard, and the machine is entirely self-contained, even to the point of being equipped with a crane for handling the spindle when changing wheels. The floor space occupied is 6 by 6 feet, and the machine weighs 6000 pounds.

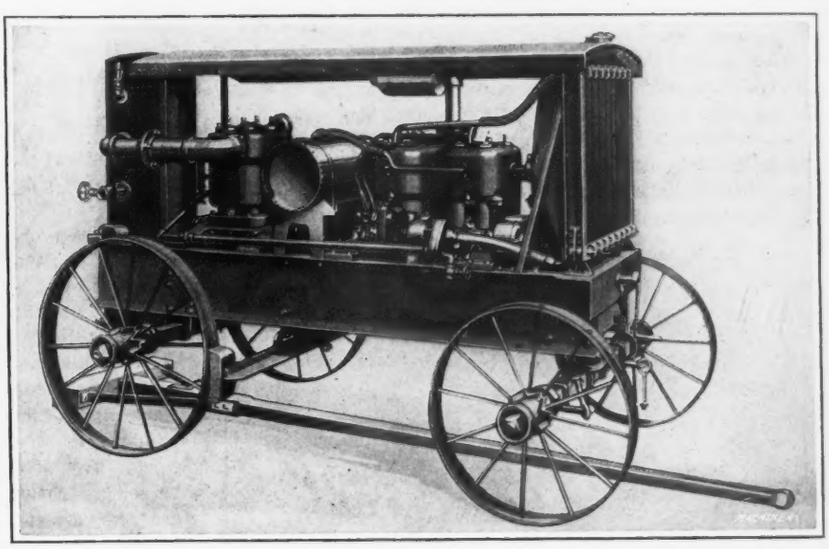
SILVER RADIAL DRILLING MACHINE

The Silver Mfg. Co., 385 Broadway, Salem, Ohio, has recently added to its line of drilling machines a radial drilling machine which is built in 2½-, 3-, and 3½-foot sizes. Simplicity of design and convenience of operation are features of these machines. The column is made of semi-steel and accurately ground to size. It is of an improved design in which the inner column or post has a wide bearing on the base and extends to the top without taper. In addition to an amply proportioned bearing at both the top and bottom, there is a middle bearing, which adds greatly to the rigidity. The outer column telescopes the post and rests on a ball bearing which facilitates easy movement of the radial arm. A clamping device is situated within easy reach of the operator, and it may be manipulated either by hand or by a foot-treadle. The arm is of pipe section and is furnished with an exceptionally wide bearing on the column. An automatic knock-out is placed at both the upper and lower limit positions of the vertical travel of the arm. Provision is made for clamping the arm to the column by two levers, which are conveniently located for the operator. A large handwheel operating through a rack and hardened spiral pinion enables the operator to run the head rapidly along the arm.

It will be noted that the design of the head is worked out in such a way that a wide bearing is afforded for the spindle sleeve. The back-gears are mounted on the head and provide two speeds, these gears being of the sliding type, so that they may be shifted while running, the change being effected by a lever located at the right-hand side of the spindle. The spindle is made of high-carbon crucible steel accurately ground to size. The spindle sleeve is bushed with phosphor-bronze, and the rack teeth are cut directly in the sleeve. A ball bearing supports the thrust load. Eight changes of feed are obtainable, these changes being arranged in geometrical progression from 0.005 to 0.040 inch per revolution of the spindle. Any available rate of feed may be obtained while the machine is running. Six changes of speed may be quickly obtained, and this number is multiplied by the back-gears on the head, giving a total of twelve speed changes. With the speed-box these cover a range of from 38 to 321 revolutions per minute and when the machine is equipped with a six-step cone pulley, the available speed changes are from 32 to 321 R. P. M.

INGERSOLL-RAND PORTABLE AIR COMPRESSOR

The Ingersoll-Rand Co., 11 Broadway, New York City, has recently introduced a portable, light-weight gasoline engine driven unit, built in two sizes, to be known as the "Imperial" Type 14 portable air compressor. These are all-steel outfits, from their sheet-steel canopy to the broad-tired steel wheels. The power plant of each consists of a duplex vertical compressor, driven at high speed by a four-cylinder four-cycle tractor type of gasoline motor. It is pointed out that the outfit, being designed especially for portable use, has had unnecessary weight eliminated, and affords maximum air power output per unit of weight. The larger machine, of 210 cubic feet capacity weighs only 6000 pounds and the 118-cubic foot unit weighs 4000 pounds. A point is also made of the fact that gasoline motor drive provides power in an economical form and in a mechanism that can be confidently entrusted to the average operator, for men familiar with gasoline engines are everywhere available and make thoroughly competent engineers.



"Imperial" Type 14 Portable Air Compressor built by the Ingersoll-Rand Co.

The compressors have cylinders cast en-bloc, with cylinder heads, valve chambers, and water jackets integral. Both intake and discharge valves are of plate type and are located directly over the cylinder bore. The crankshafts and connecting-rods are drop-forgings, and the air pistons are fitted with three-piece piston rings and, in addition, with an oil wiper ring. This latter returns all surplus oil from the cylinder walls to the crank-case, and is claimed to obviate the difficulty caused by having the air carry an excess of oil into the receiver. All bearings are die-castings of anti-friction metal. Hand-holes in the crank-case permit convenient access for adjusting the main bearings and those of the crankpins. All parts are lubricated by splash from an oil reservoir in the crank-case.

The compressors are provided with inlet unloading devices which automatically close the compressor intake when the receiver pressure rises above a predetermined limit, and permit the machine to again take up its load when the pressure has fallen a definite amount. The gasoline driving motors are of long stroke type, and operate at medium speed. They are equipped with high-tension magneto ignition, with automatic governors to maintain constant speed under all working conditions and to prevent overspeeding when idling. A splash oiling system lubricates all moving parts. The starting crank is located at the front of the machine beneath the radiator.

Both the compressor and driving motor are water-cooled by a circulating system, with a centrifugal pump, large radiator and powerful blast fan. Attention is directed to the fact that the radiators are made up of removable sections, a construction which allows the removal and repair of a damaged section without taking down the entire radiator or interrupting the use of the compressor. Each of these units is equipped complete with a receiver, safety valve, drain valves, pressure gage and service valves to which the air hose lines may be attached. When the fuel tank has been filled, lubricating oil provided, and the cooling system supplied with water, the units are ready for work. The mounting of the machines is worthy of note, particularly the swiveled front axle which moves freely in both horizontal and vertical planes. This, with the rigidly attached rear axle, gives a three-point suspension and permits the outfit to pass over inequalities of the ground without any racking effect or misalignment of the power plant. The two sizes differ in respect to the location of the air receiver and in minor details of design.

"INANOUT" DOUBLE-ACTING COLLET

The Inanout Collet Mfg. Co., Inc., 821 Lake Ave., Rochester, N. Y., has commenced the manufacture of a line of double-acting spring collet chucks. Fig. 1 shows the collet in section, and Fig. 2 shows some of the varied forms of chucks made by the company, as well as the adapters and draw-in bar used in connection with them. In principle, the chuck is very simple. In addition to the regulation closing taper that is common to all collet chucks, this chuck is fitted with an integral steel flange, on the inner face of which is a reverse or expanding taper. The outer surface of the chuck is fitted with standard sized shoulders for holding internal work.

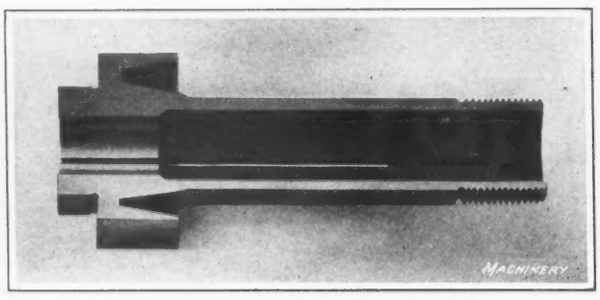


Fig. 1. Split Collet made by the Inanout Collet Mfg. Co., Inc.

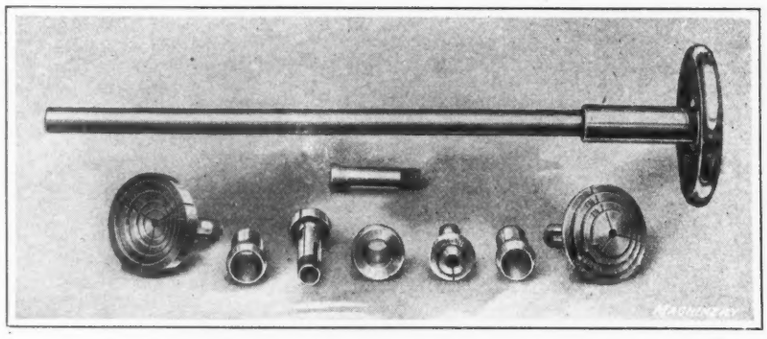


Fig. 2. Examples of Chucks made by the Inanout Collet Mfg. Co., Inc.

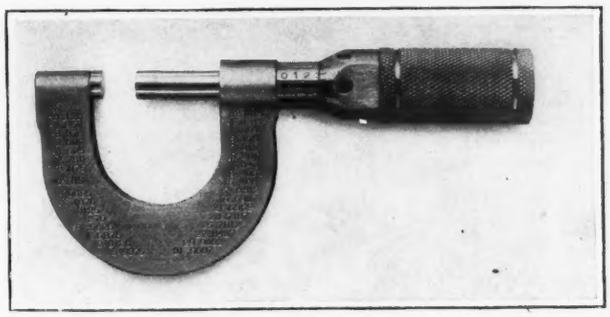
By means of adapters, which act either on the expanding tapered section or on the regulation tapered section, the collet may be expanded for gripping internal work or contracted for gripping external work, according to which adapter is used. These "Inanout" collets are made of the best tool steel, hardened and ground to standard sizes, both in the bore and at the steps used for internal gripping. As will be seen in Fig. 2, multiple step collets for special purposes may be obtained. These collet chucks are made for use in any of the standard bench and tool-room lathes, and if desired, chucks of special dimensions will be furnished for special work. Special collets may be had for holding threaded sections, either internally or externally.

ZUBAR WELDED TIP TOOLS

The idea of welding a tool shank made from inexpensive material to a cutting tip made of high-speed steel or some other expensive metal is not new to men of considerable mechanical experience. The ZuBar Mfg. Co., Inc., 5701 McMahon Ave., Germantown, Philadelphia, Pa., has recently engaged in the manufacture of welded tipped tools by a process which does not involve the use of a sufficiently high temperature to damage the steel. A process of welding is employed by which the high-speed steel tip may not only be satisfactorily hardened and tempered, but it is claimed that the physical properties of the metal are improved. Tools made by this process are produced in all standard shapes and sizes, and also special tools that it would be difficult to make from solid pieces of high-speed steel, and which as a consequence are often made of carbon steel. All tools made by this company are ground ready for use.

CENTRAL TOOL CO.'S DIRECT-READING MICROMETER

An improved type of direct-reading micrometer has recently been placed upon the market by the Central Tool Co., of Auburn, R. I. This is known as the "Jaques" easy-reading micrometer, and is sold by the Production Equipment Co., Inc., 1 Madison Ave., New York City. One of the advantages of this tool is the fact that it is so simple to read that anyone without a knowledge of the principles governing the operation of a micrometer can use it quite easily. Instead of having forty graduations on the barrel as in the case of standard micrometers, there are only ten graduations, and it is only necessary to glance at the little dial windows in order to read directly the full dimension of the work. The first decimal of the reading is taken from the barrel graduation, while the second and third decimal places are read direct from the dial. Another feature that is of value in this micrometer, is that although it is provided with a dial mechanism, giving the easy reading feature, it is very

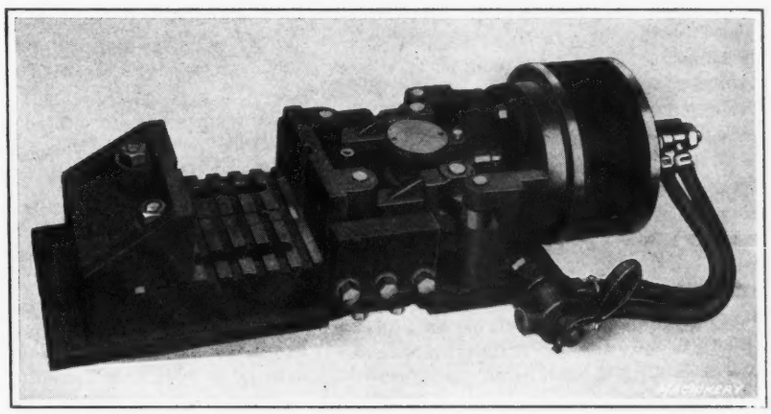


Direct-reading Micrometer made by the Central Tool Co.

little larger than a regular micrometer, and is just as light to carry. Micrometers of this type are made in sizes up to 12 inches, either with or without ratchet stops. They may be furnished with graduations to read to 0.0001 inch. The direct-reading feature enables a micrometer of this type to be read very rapidly, as there is no delay in arriving at the desired result.

MANUFACTURERS EQUIPMENT CO'S AIR-OPERATED VISE

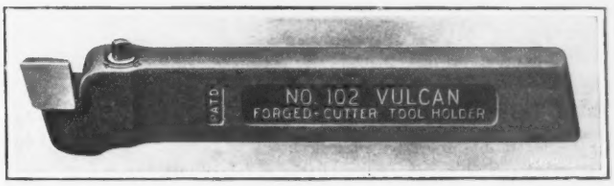
For use in holding work on milling and drilling machines, the Manufacturers Equipment Co., Waller and Fillmore Sts., Chicago, Ill., has recently placed upon the market an air-operated vise. It is so constructed that either a six-inch or eight-inch air cylinder can be used. Power from the cylinder is transmitted through a system of compound levers which multiply in the ratio of 2 to 1, thus affording a powerful grip on the work. The jaws are 3½ inches high by 8 inches wide, and the power stroke of the compound levers is ½ inch. It is stated that ample power is provided to hold work under the most severe conditions of operation for which a vise of this size is adapted.



Air-operated Milling and Drilling Machine Vise made by the Manufacturers Equipment Co.

J. H. WILLIAMS "VULCAN" TOOL-HOLDER

J. H. Williams & Co., 61 Richards St., Brooklyn, N. Y., have recently added to their line what are known as "Vulcan" forged-cutter tool-holders. It is said that these holders constitute the equivalent of a solid tool, and that they meet the requirements of those who prefer solid forged tools to the regular tool-holder. The construction of the "Vulcan" forged-cutter tool-holders eliminates the high cost of the solid tool and at the same time retains many of its advantages. By merely inserting a small high-speed forged cutter, each holder is adapted for taking the heaviest cuts that are involved in the performance of any regular machining operations on lathes, planers, shapers, etc. A supply of cutters may be maintained in readiness for instant service by the man in charge of the tool-room, with a negligible amount of expense for grinding, so that the machine operator may always have an ample stock of tools ready to meet his needs. Duplicate lines of important shapes and sizes may be carried with only a slight additional investment, and this practice insures the operator against delay. The holders are all drop-forged from a special grade of steel, and so heat-treated that the maximum toughness and stiffness is obtained. They are of simple construction and consist of three parts, namely, the holder, the square-headed cam, and the locking pin, the design being such that the cutter is immovably held. The cutters are drop-forged from high-speed steel, and are finished and hardened ready for use. They are furnished in a wide range of sizes and types, such as side, diamond point, roughing, hog-nose, threading, etc.

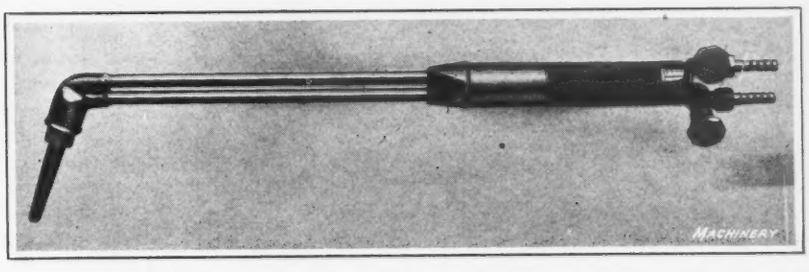


"Vulcan" Forged-cutter Tool-holder made by J. H. Williams & Co.

"AIRCO" WELDING TORCH

A new welding torch, capable of meeting the varied requirements of modern welding, has been introduced by the Air Reduction Sales Co., 120 Broadway, New York City. This "Airco" welding torch is of very strong construction, yet at the same time, it is so light and well balanced that the operator will not experience strain when welding a long job. The handle is knurled and comfortably proportioned, so that a firm grip can be secured without undue pressure. An interesting feature in this connection is a gas pressure table rolled on the upper part of the handle. Such a table is very handy for reference and this location proves a convenient and lasting place for the information. The valve handles are of octagon shape. They are easily turned and will not catch in the operator's work or clothing. Both the handles are on the left side. With this construction and with the hose connections extending straight out from the valve body, there is nothing to interfere with the proper manipulation of the torch.

All passages are so designed and the parts so assembled as to insure an easy flow of gas. The tubes between the head and handle are of hard drawn seamless brass, countersunk at both ends. The torch is silver soldered, and the valve body and butt of the handle are in one casting. The valve body will not work loose or break off. The gases are mixed at the entrance to the discharge passage of the tip, and there is no premature mixing or mixing in other than the predetermined quantities. Whenever a new tip is put



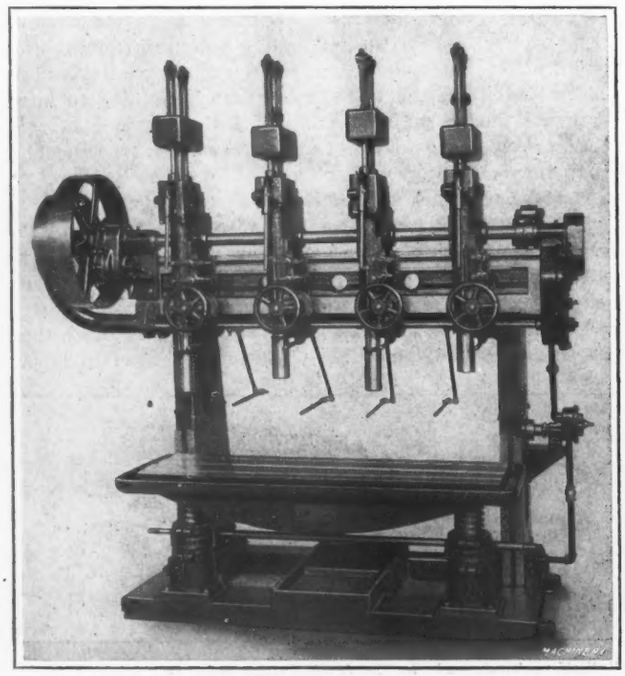
"Airco" Welding Torch made by the Air Reduction Sales Co.

in place, the mixture is automatically proportioned to the size of the tip. The mixture produced in the "Airco" torch approaches close to the theoretical proportion of one part of oxygen to one part of acetylene, effecting the maximum possible economy in gas consumption.

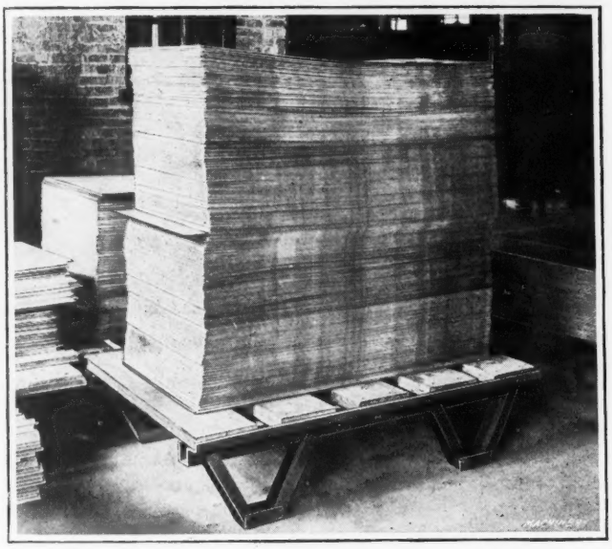
The conical projection of the head cooperates with the conical recess of the tip in a metal-to-metal seat, the tip being held securely in place by a tip nut. This practice does away with the threads on the tip as well as eliminating outside threading on the head. The tip is made of a special alloy selected after an extensive series of heat and endurance tests. The acetylene grooves are accessible and but a few seconds are required to remove carbon if cleaning becomes necessary. The torch head is drop-forged of the same material as the tip, so that both these parts are subject to the same coefficient of expansion and contraction. The manufacturers have adapted the apparatus to a wide range of work by making it in four different sizes which are adaptable for all classes of welding from sheet metal to heavy castings. Different heads are also provided for special requirements. A range of tips is available providing flames from the smallest to the largest required in general practice.

HARRINGTON MULTIPLE-SPINDLE DRILLING MACHINE

In the accompanying illustration there is shown a No. 17 multiple-spindle drilling machine which is a recent product of Edwin Harrington, Son & Co., Inc., 17th and Callowhill Sts., Philadelphia, Pa. The machine here illustrated has four spindles, but the number of spindles can be varied to meet the requirements of different consignees; also, tables can be furnished in several different types to meet the requirements of different classes of work. Where the regular frame sizes do not meet the requirements, special frames can be furnished to order, which cover a considerable range of sizes, and if desired, provision may be made for connecting adjacent heads to move them along the cross-rail in pairs. The driving pulleys transmit 12 horsepower, which is ample for efficiently driving four 1-inch drills in mild steel at all practical rates of speed and feed. Larger drills can be used where all of the spindles are not working at one time, or where light feeds are employed. It will be seen that the spindle heads are mounted directly on the face of the cross-rail on which they have independent lateral adjustment by a rack and hand-operated pinion, and they are clamped in position by bolts and a gib in the T-slot of the cross-rail.



No. 17 Multiple-spindle Drilling Machine built by Edwin Harrington, Son & Co., Inc.



Steel Legs made by the Lyon Metallic Mfg. Co. for supporting Elevating Truck Platforms

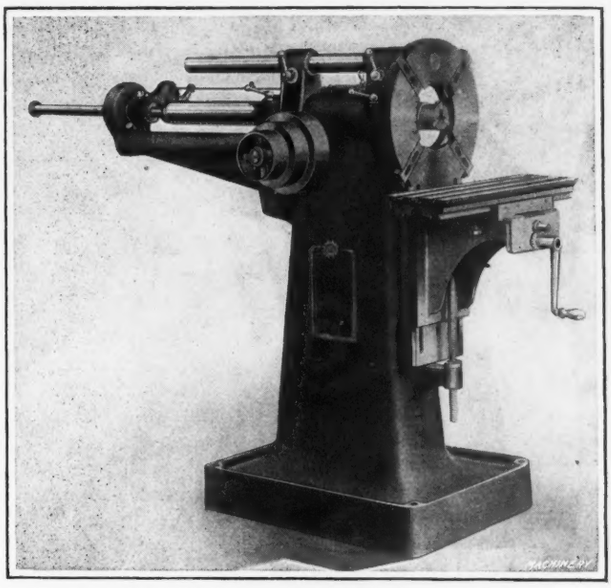
LYON ELEVATING TRUCK PLATFORM LEGS

Trouble is often experienced from several causes, where homemade wooden skids are used in handling heavy loads on elevating trucks. Such skids are likely to be very bulky and cumbersome, or else the legs are likely to be weak and to wear down, so that the skids require frequent repairing. To obviate such difficulties, the Lyon Metallic Mfg. Co., Aurora, Ill., has developed a steel skid leg of the type shown attached to a platform in the accompanying illustration. The fully loaded platform is supporting seven tons of metal which, of course, is a heavier lead than could be lifted on an elevating truck.

This new skid leg consists of two feet which are welded to a steel channel that is provided with bolt holes spaced in such a way as to make it an easy matter to bolt the legs to either a wooden or steel skid. Rounded corners and a wide bearing for the feet prevent them from damaging the floor, and the channels are of ample strength to resist all stresses to which they are likely to be subjected. Another feature of these legs is that additional supplies of platforms may be carried in stock, knocked down so that they take up very little space but are instantly accessible for use. The wooden cross pieces can be drilled to fit skid legs which are punched to standard patterns. All that is necessary to have a new platform ready for use is to withdraw the required number of cross pieces from stock and bolt them to the steel legs. The platforms may be made of any width, as the cross pieces can be cut to any desired length.

"KRIESEL" BORING, MILLING AND DRILLING MACHINE

To meet the requirements of automobile repair shop work where there are a variety of different machining operations to perform, but where the quantity of any one kind of work is often insufficient to justify investment in a variety of standard types of machine tools, the Mill City Co., 823 Plymouth Bldg., Minneapolis, Minn., has recently placed upon the market the "Kriesel" multi-purpose machine, which is here illustrated and described. It is claimed that this is a complete but simplified machine for performing boring, milling, and drilling operations, and not only is its first cost much less than that of individual equipments, but the amount of floor space occupied is also far less. In addition to its application in automotive repair shops, this machine is said to be well suited to the requirements of certain classes of tool-room work. The frame and base are cast in one piece to provide a rigid construction, and the machine is of exceptionally simple design, so that its use may be readily



"Kriesel" Boring, Milling and Drilling Machine built by the Mill City Co.

mastered by men of limited experience. The provision for performing boring, milling, and drilling operations on a single machine, when combined with a reasonable amount of ingenuity on the part of the operator, will enable a machine of this type to handle a great variety of work which must be done in the average automobile repair shop. The machine weighs 1000 pounds.

MICHIGAN CYLINDER BORING AND BURNISHING TOOL

For use in garages and repair shops that are called upon to refinish cylinders of engines for Ford passenger cars and Fordson tractors, the Michigan Machine Co., Detroit, Mich., has recently developed a combination boring and burnishing tool. This equipment is designed in such a way that it locks on the cylinder block and may be operated either manually or by power. To provide for refinishing one of the bores in a cylinder block, face *A* of the tool is secured to the top of the work by means of cap-screws which enter the tapped holes in the block. Two gages *B* are made of such thickness that they enter the space between the cylinder bore and barrel *C* of the tool, thus locating the tool concentric with the bore of the cylinder. Attention is called to the fact that the portion of the cylinder bore which is engaged by gages *B* always remains accurate, because it is not subjected to the rubbing action of the piston. Locating the tool from this part of the cylinder, assures accuracy in reboring. In addition, the tool is clamped by a supporting member *D* which is secured to the bottom of the cylinder block, but this support is entirely supplementary; it performs no essential function in the operation of the tool. Gage-blocks *B* are removed, after the tool has been clamped in place.

After the tool has been set up on the work, the first step is to rebore the cylinder by means of cutter *E*, and after this has been accomplished, the burnishing head *F* provides for imparting a high finish to the work. A screw *G* will be seen extending through the middle of barrel *C*, and in the case above flange *A* there are a differential gear drive and a plain gear drive. By shifting crank handle *H* into its three successive vertical positions, provision is made for obtaining either a differential geared drive which rotates both barrel *C* and screw *G*, a plain geared drive which rotates barrel *C*, or a direct connection between screw *G* and crank *H* to provide for simply rotating the screw. In starting to refinish a cylinder, the first driving position is employed in order that both the barrel *C* and screw *G* may rotate. The differential gears are so designed that the relative motion between the barrel and screw results in imparting a downward feed movement of 1/64 inch per revolution to the boring tool *E*.

After the cylinder has been bored, the position of the driving mechanism is changed to obtain a direct-connected drive between the screw *G* and crank *H*, in order that the screw may be rotated in the opposite direction to provide for backing the boring tool up into the head; that is to say, in the position shown in the illustration. Then the clamping bar *D* is removed and burnishing head *F* is slipped into place over the barrel *C*, after which bar *D* is again replaced and the driving mechanism is adjusted to provide for simply rotating the barrel *C*. The hardened steel burnishing rollers carried in head *F* are set at a slight angle to the axis of the head, and as a result of this inclined mounting, a feed movement is imparted to the head which slides in the spline groove in barrel *C*. No screw or other positive means of transmitting power is used to accomplish the feeding of the burnishing head. The burnishing rollers are tapered at each end to prevent them from scoring the cylinder and thus damaging the finished surface of the work.

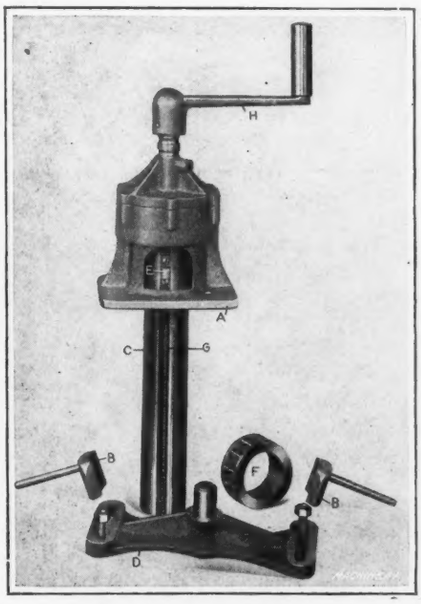
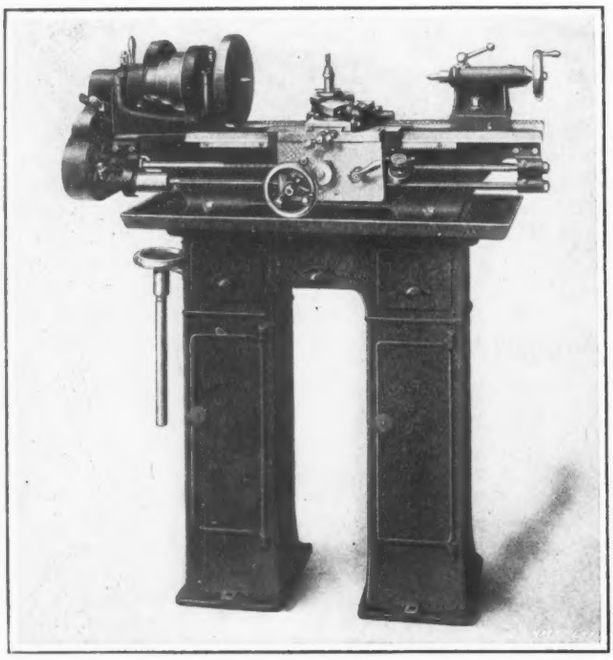


Fig. 1. Cylinder Boring and Burnishing Tool built by the Michigan Machine Co.

Fig. 2. Use of the Michigan Cylinder Boring and Burnishing Tool shown in Detail in Fig. 1

"DALTON SIX" MANUFACTURING LATHE

One of the recent developments of the Dalton Mfg. Corporation, 1915 Park Ave., New York City, is the 8-inch lathe which is illustrated herewith. The ways on the back of the lathe bed are finished square with the horizontal surface and have machined T-slots extending their entire length so that the various special attachments, which may be furnished with the lathe, can be accurately applied thereto. The length of the bed is 36 inches and with the bench type machine is set on short legs, while the floor type is supported either by standard high legs or on a high cabinet base, such as shown in the illustration. This casting, as may be clearly seen, contains drawers for tools and collets, as well as two closets in which certain special attachments, change-gears and similar parts may be conveniently kept. Each of these compartments has three removable steel shelves and the



Manufacturing Lathe built by the Dalton Mfg. Corporation

drawers are made of sheet metal, electrically welded.

The headstock is of heavy web construction, well ribbed, and is equipped with bronze bearings which are lubricated by sight-feed oilers. The drop-forged steel spindle contains a large hole and is mounted in thrust ball bearings. The entire spindle is ground outside, including threads at the nose. The carriage is securely gibbed, front and back, and is provided with felt wipers for removing particles of dirt and furnishing lubrication for the ways when the carriage travels. The compound rest base is graduated 180 degrees and is clamped in a circular T-slot in the cross-slide. The compound rest is offset 60 degrees so that in performing threading operations the tool is more readily accessible to the work. Both the compound rest feed-screws and the cross-feed screw for the slide have micrometer adjustment. All bearings in the apron are separate bushings which are screwed into the casting. An oil trough is provided in the apron casting in which the feed-rod worm and gear revolve.

The tailstock is offset and has a liberally proportioned foot with a crosswise tongue which fits in the tailstock base, thus permitting side adjustment for taper turning operations. The lead-screw can be furnished either with English or metric pitch screw threads and is made from high-carbon steel. The countershaft is of special design and can be attached either to the wall or hung from the ceiling. A special countershaft is provided when the grinding attachment is furnished and operates in connection with the regular countershaft. Countershaft bearings are ring-oiled and the driving pulleys are provided with roller bearings. When the lathe is arranged for foot power or for motor drive the countershaft is not, of course, regularly furnished. For motor drive a 1/3-horsepower motor is mounted on a bracket directly above the cone pulley.

The variety of special attachments, provision for the application of which has been especially made in designing the ways, furnishes a wide range of service for performing many different classes of work. Some of these special attachments include taper attachment, quick-acting draw-in attachment, chasing dial, broaching attachment, automatic turret on bed, double toolpost, indexing attachment, milling attachment, gear-cutting attachment, Fox thread-chasing attachment, grinding attachment (both internal and external), grinder attachment for motor-driven lathe, lathe and drill chucks and various types of arbors, centers, etc.

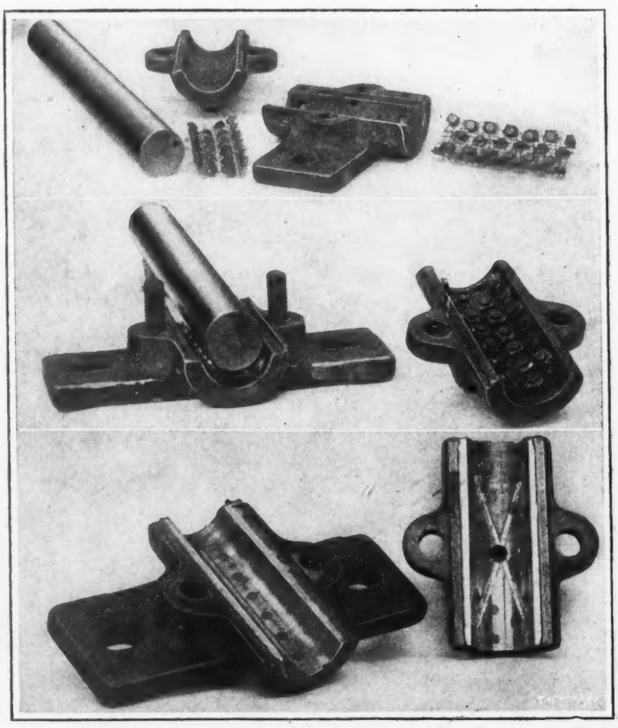
The actual swing over the bed is 8¼ inches, over the carriage 5 inches, and over the compound rest, 1⅞ inches. The distance between centers is 18½ inches, and the over-all length of the machine, when the tailstock is at the extreme position, is 45 inches. With the English lead-screw, threads from 3 to 72 per inch may be cut; while the use of the metric lead-screw enables threads having a pitch of from 0.25 millimeter to 6 millimeters to be cut. The back-gear ratio is 6.5 to 1.

RANDALL GRAPHITE SHEET LUBRICATOR FOR BABBITTED BEARINGS

To provide for facilitating the lubrication of babbitted bearings through the use of graphite, the Randall Graphite Sales Co., 711-721 Fulton St., Chicago, Ill., is making what is known as the Randall graphite sheet lubricator. The accompanying illustration shows successive steps in the process of babbitting a bearing in which one of these lubricators is to be employed. The device consists of a wire mesh on which there are mounted graphite cones which are made from an especially prepared binder and pure Ceylon flake graphite which is finely ground and air separated. The method of preparing the material is such that the graphite cones are absolutely free from cutting properties, and they are said to wear uniformly with the babbitt, showing no tendency to crumble, get soft, or wash out of the bearing.

These sheet lubricators are packed twelve sheets in a box, each sheet measuring approximately 12 by 12 inches in size, and they may be furnished with cones of 1/8, 5/32, 3/16, 7/32, 1/4, 5/16, and 3/8 inch in size, so that a selection may be made of the proper lubricator for a variety of different sizes of bearings. The graphite cones are slightly tapered, and are firmly attached by the application of hydraulic pressure to a fine bronze wire screen or fabric, the cones being located in a staggered formation. It will be apparent from the illustration that the sheet lubricator is applied at the time that the bearing is being babbitted. The lubricator is cut to the proper size and placed in the bearing housing before pouring the babbitt, after which the operation is performed in the usual way. The babbitt metal flows into place and sets firmly around the cones, making them an integral part of the bearing and enabling advantage to be taken of the well known lubricating properties of graphite.

The claim is made that babbitted bearings prepared in this way use from 75 to 90 per cent less lubricating oil, and

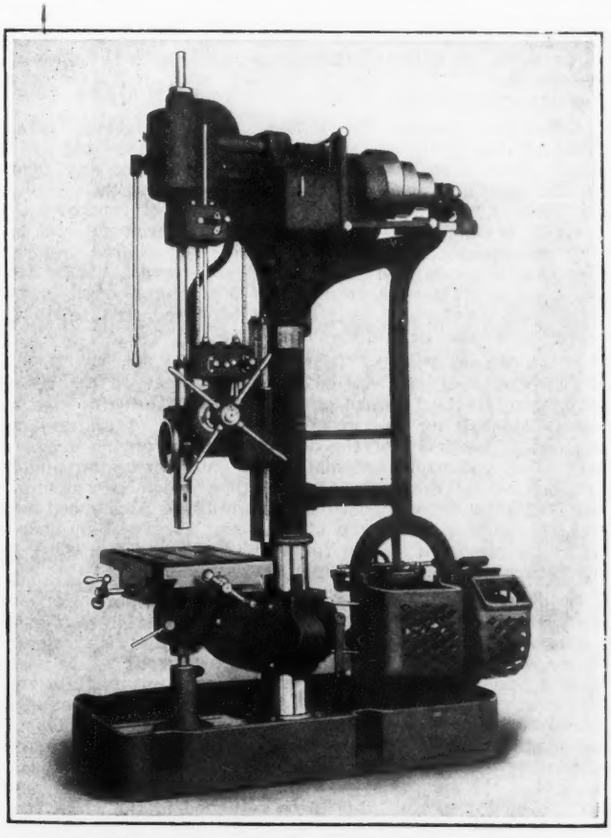


Successive Steps in applying the Randall Graphite Sheet Lubricator to Babbitted Bearings

that they will last three times as long as plain babbitted bearings. This result is due to the tendency for the graphite to fill the porous surface of the shaft and bearing, making these members absolutely smooth and reducing frictional resistance to a minimum. The graphite buttons also absorb oil and provide reservoirs which feed oil back to the bearing, a sufficient quantity of oil being made available in this way to allow the bearing to run for a considerable period of time without damage, in case the attendant neglects to oil the bearing. It is also claimed that the wire fabric of the Randall graphite sheet lubricator constitutes a reinforcement for the babbitt which greatly increases its strength and durability, thus increasing the life of the bearing. In babbitting split bearings or bushings, the sheet is crimped as shown in the illustration, thus forming a spring with the crimps against the back of the casting, while the small end of the graphite buttons fit snugly against the shaft or mandrel. This allows the metal to flow in back of the sheet. For solid bearings, the sheet is flat and simply bent around the mandrel, after which it is tied in place with a fine wire until the babbitt has been poured.

OIL-PAN FOR WEIGEL DRILLING MACHINE

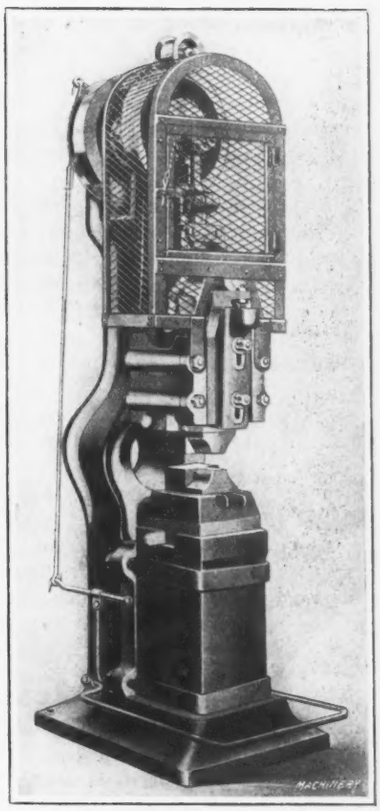
In the February number of MACHINERY a description was published of a 21-inch upright drilling machine built by the Weigel Machine Tool Co., Peru, Ind. The accompanying illustration shows a 25-inch machine of similar design, except that it is equipped with a deep oil-pan around the base. This pan is 6 inches wide by 8 inches deep, and it comes 4 inches above the top surface of the base. The pan is cast integral with the base. Where a large volume of coolant is required, this pan is of ample size to accommodate it, and the coolant can be pumped direct from the base and allowed to flow back to the reservoir without spattering on the floor. Bolts for bolting the machine down on its foundation are placed outside of the oil-pan, so that there is no danger of leakage through the bolt holes. Oil-pans of this type can be supplied on both the 25- and 21-inch Weigel drilling machines.



Weigel 25-inch Drilling Machine equipped with an Oil-pan Base

UNITED HAMMER GUARD

The United Hammer Co., Oliver Bldg., Boston, Mass., has developed a guard for use on Fairbanks power hammers, which completely covers the working parts of the machine and prevents any possibility of injury to the operator, although it leaves the mechanism accessible for the purpose of oiling or adjustment. Another feature of the guard is that it is easily attached to hammers which have already been placed in operation. This guard is furnished as a regular part of the equipment of new hammers. It will be evident that access to the mechanism for oiling or adjustment is through a door at the front of the guard.



Fairbanks Power Hammer equipped with Guard recently developed by the United Hammer Co.

CARBORUNDUM CO.'S NEW ALUMINOUS ABRASIVE

Present-day grinding operations have become such a highly specialized work that abrasive manufacturers have found it necessary to carry on constant experimental and development work, always with the idea of perfecting abrasive materials and making grinding wheels that will definitely meet the exacting needs of the grinding conditions of industry. For some time the Carborundum Co., Niagara Falls, N. Y., has felt that industry needed an abrasive which could be bonded into a wheel having extraordinary sharpness, fast cool cutting ability, uniformity and long life—a wheel that would not only have these qualities, but at the same time would be what might be termed an open "brittle" wheel so far as its structure was concerned. Such a combination of grinding virtues, it has been found, was extremely necessary in the grinding wheels that are principally used in the grinding of high-speed and casehardened steel, and for the work of surface grinding.

After a long period of research the Carborundum Co. has perfected a new abrasive material having characteristics which appear to be well suited for the grinding of reamers, cutters, hob-mills and for other small tool-room work; and in addition, this new abrasive is found to be perfectly adapted for certain cylindrical grinding operations, such as the grinding of the shanks of high-speed drills, the rollers for roller bearings and for grinding the sides of washers for thrust bearings. Still another field in which this new abrasive is destined to show marked efficiency is in the surface grinding of broad surfaces on vertical grinders, particularly where a large amount of stock is to be removed in a short time. This new abrasive material is to be known as aloxite AA. It is now being made in large quantities, and grinding wheels made from this product are available for all uses for which it is intended.

The bulk of the aluminous abrasive now used in grinding operations contains from 92 to 96 per cent of alumina, 2½ to 4 per cent of titanium oxide, ½ to 1 per cent of both iron oxide and silica, and lesser amounts of lime and mag-

nesia. Most of the alumina is present in the crystallized state, while the other impurities combined with a small portion of the alumina form a glass which functions as a matrix or cement, holding together the crystals of alumina. These crystals are composed of practically pure alumina and have all the characteristic hardness of our natural jewels, the ruby and sapphire. The shape and size of these alumina crystals and the amount of matrix present have an important bearing upon the characteristics of the abrasive, and a study of the internal structure of the abrasive is of great importance. The method now generally used for this investigation is by means of thin sections cut from a massive lump of the abrasive. A microscopic study of these thin sections shows the size and shape of the alumina crystals and their arrangement.

The amount of impurity present in the new abrasive is about 1.5 per cent or very much less than is found in the ordinary type of aluminous abrasive. This decreased amount of impurity has an important bearing on the characteristics of the abrasive grain and the wheel made from it. The cutting power is increased, due to the greater amount of crystallized alumina present. There is less fluxing between the bond and the grain, which results in a brittle wheel so necessary for rapid cutting. It also makes possible, due to the high purity of the grain, the production of wheels of very soft grade. The small amount of impurities allowed to remain in the abrasive is not objectionable but on the other hand is extremely beneficial. This impurity prevents the formation of skeleton crystals and prevents the more or less open and porous structure which is obtained when molten pure alumina is allowed to solidify. The resulting abrasive consequently exhibits a greater toughness and imparts a longer life to the wheel.

The large size of the alumina crystals in aloxite AA have an important bearing on the cutting power of the abrasive. As the grits commonly used are 20 and finer, almost every individual grit will consist of a fragment broken from a larger crystal of alumina and, due to this fact, possesses exceptional sharpness. During the process of grinding there is a breaking down of the abrasive grains in a wheel, and the character of the new grains that are formed depends largely upon the size of the alumina crystals in the original abrasive. When the alumina crystals in the abrasive are small, a rupture of the grain may mean a tearing away of a few small crystals without fracture. However, when the crystals are large and a rupture occurs in an abrasive grain, it means that a crystal of alumina has been actually fractured and that new sharp cutting points and edges have been produced. In summing up briefly it may be said that aloxite AA is composed of nearly pure alumina with just enough impurity present to produce a desirable toughness and furnish an abrasive which will have a long life when used in a grinding wheel. It has great hardness and its remarkable sharpness is due to the large size of the crystals of alumina in the abrasive. It is possible to manufacture from this high purity grain a bonded wheel of brittle nature and of soft grade. Aloxite AA wheels are uniform in grade and of open structure.

NEW MACHINERY AND TOOLS NOTES

Limit Snap Gage: American Gage Co., Newark, N. J. An adjustable "Go" and "Not Go" snap gage which is made in twenty-one sizes to give all dimensions from 0 to 12 inches.

Covered Welding Wire: Reid-Avery Co., 1436 Brandywine St., Philadelphia, Pa. A special covered electrode for use in electric arc welding, which is sold under the trade name of "Raco," derived from the initials of the company's name.

Oilless Bearing: Massachusetts Oilless Bearings Co., Worcester, Mass. A self-lubricating bearing which is known as the "Cole graphite matrix bearing," and consists of a mixture of graphite with any bearing metal alloy possessing the required physical properties for the installation in which the bearing is to be used.

Knurling Tool: Austin Tool & Machine Co., Pittsburg, Pa. A knurling tool which is so designed that it makes a full impression in any metal and is said to impose a minimum amount of strain on the machine or the work. The knurling rolls are carried on hardened steel pins mounted on two parallel bars, and the knurling rolls are impressed upon the work by means of an eye-bolt and wing-nut secured to the parallel bars.

Control Panel for Welding Unit: Wilson Welder & Metals Co., 2 Rector St., New York City. This apparatus consists of a motor-generator set and current control panel, and it is designed to produce a constant heat for electric welding. A normal voltage of 35 volts is maintained at the terminals of the generator. Three switches on the panel provide means of current adjustment between a minimum and maximum of 25 and 175 amperes, respectively.

Duplex Oiling Hanger Box: W. A. Jones Foundry & Machine Co., 4409 W. Roosevelt Road, Chicago, Ill. A hanger box in which the bearings are babbitted and accurately bored to size. The bearing is oiled by both a wick and rings which carry oil up from a reservoir in the base. Oil which works out of the ends of the bearing and is thrown off the shaft is caught in pockets and returned to the reservoir for subsequent use. Bearings of this type are made in all standard shaft sizes.

Reversing Lubricant Pump: Fulflo Pump Co., Blanchester, Ohio. A reversing centrifugal pump which is a self-contained unit, driven through the medium of internal spur reducing gearing that receives power from a belt drive. The pump is especially adapted for delivering lubricant to the cutting tools used on metal-working machinery. The pad on which the pump is located is detachable, and it can be placed in any of three positions, which facilitates the mounting of the pump on a machine.

Gang Drilling Machine: Bement Miles Works of the Niles-Bement-Pond Co., Philadelphia, Pa. A multiple-spindle machine for use in drilling steel plate frames for locomotives. This machine is designated a locomotive plate frame drilling machine, and it consists of a battery of four radial drilling machines with their arms fixed as regards vertical adjustment. These machines travel along a bed, so that the desired setting may be obtained. The work-table is mounted at the front of the bed and has provision for clamping the work on both horizontal and vertical surfaces.

Temperature Controller: Wilbride Co., Norwood, Pa. A device for controlling the temperatures of gas furnaces, lead pots, ovens, etc., where gas is used as a fuel. This device is operated by air pressure and consists of a controlling instrument and an automatically manipulated valve for the gas. The controlling mechanism consists of a galvanometer and an air motor, with a clamping mechanism for holding a plate on the galvanometer pointer at intervals of four seconds, when air is forced through an opening in the plate and causes the valve to operate the gas and air valves which regulate combustion.

Crankshaft Lathe: Crank Shaft Co. of America, Edison Bldg., Chicago, Ill. A machine capable of handling crankshafts from 7 to 10 inches in diameter and of any throw. It also machines the sides of the webs and makes provision for turning the ends of the cranks on all of the throws at a single setting of the work. An idea of the wonderful productive capacity of this machine will be gathered from the fact that it is claimed to have reduced the machining time on a certain class of crankshaft from thirty days to two days, namely, 6.7 per cent of the time required to do the work by a less suitable method.

"Both Ways" Planing Tool: Otto H. Cronau, 330 E. 87th St., New York City. A tool designed to cut on the return as well as on the forward stroke, thus making provision for greatly increasing the productive capacity of planers and shapers. The body of the tool is a drop-forging made of mild steel and pack-hardened. Two small swinging holders are carried by the tool body, each of which has a square hole broached through it to take a standard high-speed steel tool bit. The holders are pivoted and arranged in such a way that one lifts on the forward stroke and the other on the return stroke of the planer or shaper ram.

Automatic Sand-blasting Equipment: Pangborn Corporation, Hagerstown, Md. An automatic rotary table sand-blasting equipment which is designed to meet the requirements of shops which have a small volume of work to be sand-blasted, and where the pieces are of small or medium size. The rotary table is 42 inches in diameter and is half exposed outside of the dust-tight housing. Pieces to be sand-blasted are loaded, carried into the cleaning chamber and removed after they emerge from the cleaning chamber. The sand blast is of the suction type, and spent abrasive falls through the grated top of the table to be returned to the point from which the machine draws its sand. In this way the abrasive is made available for subsequent use.

Improved "Little Giant" Air Drill: Chicago Pneumatic Tool Co., 1060 Fisher Bldg., Chicago, Ill. This firm has recently made a number of important changes in the internal mechanism of its "Little Giant" air drill. An improved crankshaft and bearings are used, the crankshaft being made of heat-treated steel and supported by annular ball bearings at three points. The pinion teeth are of the stub type, assuring ample strength and a minimum amount of friction. The connecting-rods have a ball and socket bearing in the pistons, preventing side strains and undue wear on the cylinder walls. Replaceable bearings are provided to receive the crankpins, and the pistons are of one-piece construction and hardened, after which they are ground to size.

Crankshaft Milling Machines: Robert T. Pollock Co., Boston, Mass. A milling machine for finishing crankshafts, which enables a milling operation to be supplemented for the usual turning or grinding operations which are performed on this class of work. A plain multiple-spindle milling machine provides for machining the main bearings and assures bringing them concentric with the axis of the shaft. The number of spindles on the machine varies with the number of main bearings that have to be milled. A separate machine is used for milling the crankpins. It is equipped with four rotating heads for a four-throw crankshaft or additional heads where there are a greater number of throws on the work. The heads are independent of each other and each rotates on its own axis.

* * *

LIGNUM-VITAE AND SOME OF ITS MANY USES

In a recent number of the *Scientific American Supplement*, some interesting information concerning lignum-vitae is given by F. J. Record. It is stated that of all the woods in existence, true lignum-vitae is the only one that has been found equal to such service as is required for bearings for the propeller shafts of battleships, destroyers, etc. The peculiar properties of the wood which adapt it for this purpose result from the arrangement of the fibers and the resin content of the sap cells. The fibers do not run straight up and down the log, but weave back and forth in a serpentine manner, crossing and recrossing like the corded fabric of an automobile tire. The result is a material of extreme tenacity and toughness. When the sap cells cease to function, every nook and crevice becomes filled with a resin which is about a third heavier than water. The wood weighs about eighty pounds per cubic foot. There are many other uses for this valuable wood, such as rollers for casters, mallets, sheaves or pulleys, stencil and chisel blocks, dowels, wooden cogs, water wheels and block guides for band saws, etc. In building the Panama Canal, true lignum-vitae made the most serviceable railroad ties that could be obtained.

* * *

CAPITALIZATION OF AMERICAN INDUSTRIES

The total amount of capital invested in the railroads and the industries in the United States has been estimated to amount to about $39,000,000,000. This capital is distributed among the various industries as follows:

Railroads (value of roads and equipment)	$16,145,532,000
Iron and steel	4,281,998,000
Chemicals	3,034,209,000
Textiles	2,810,848,000
Food	2,174,387,000
Lumber	1,723,456,000
Paper and printing	1,433,176,000
Beverages	1,015,715,000
Metals (other than iron)	1,013,632,000
Stone, clay, and glass	987,328,000
Vehicles	803,496,000
Leather	743,347,000
Railroad repair shops	417,706,000
Tobacco	303,840,000
All other industries	2,047,842,000

It will be noted that the total investment in the industries and railroads is less than twice the amount raised by the Liberty loans during a period of two years.

FRANCE RECOVERS MACHINERY FROM GERMANY

Commercial Attaché C. P. Snow reports from Paris that the "Recuperation Service" and the "Restitution Service" of the French Ministry of Industrial Reconstruction has made a report concerning the work of identifying and returning to France of French machinery that had been carried off and made use of by the Germans. Up to the end of March the Restitution Service had shipped from Germany back to the departments in the north of France 1085 tons; at the end of May the total had gone up to 18,511 tons; and since that date substantial shipments have been made from time to time. There were also 200 carloads, with 2265 tons of machinery, shipped from Germany to Alsace, and 2980 tons found and identified in Belgium, shipped back to the original factories in the north of France. The total reshipped into the devastated regions of the north and into Alsace up to the end of May was over 21,000 tons. At that same date over 15,000 tons of identified machinery was being dismounted and loaded in Germany, and 20,000 tons more had been identified in the Grand Duchy of Luxemburg and in Germany, concerning which the representatives of the French Ministry of Industrial Reconstruction were awaiting instructions from the French manufacturers concerned.

* * *

NATIONAL SCREW THREAD COMMISSION

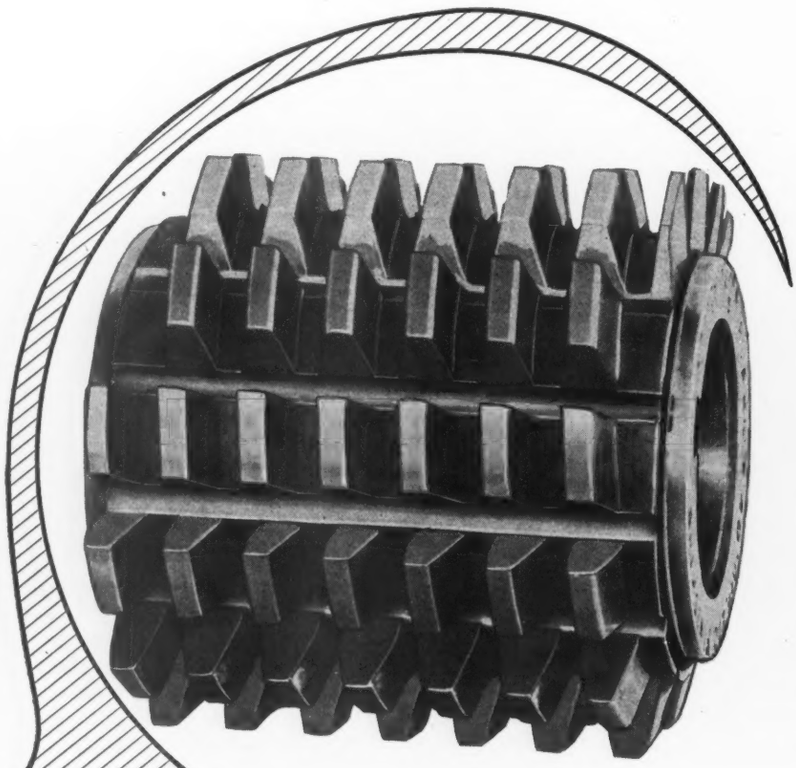
The National Screw Thread Commission has returned from Europe where it held a number of conferences in England and France on the subject of international screw thread standards. The results of the conferences and other efforts of the commission are requests from Great Britain and from France for further Anglo-American and Franco-American conferences for the purpose of arriving at an international standard for screw threads. The commission gained a broad knowledge of the art and manufacturing methods involved in screw thread production abroad, and has attained an understanding of the foreign situation to such an extent that it is felt that considerable progress has been made toward an international standard. The last public hearing in America on national screw thread standards will occur on Monday, October 6, 1919, at 10 A. M. in the Engineering Societies Building, 29 W. 39th St., New York City. The engineering bodies interested and the industries manufacturing and using screws will meet and give full and final consideration to the report. A general invitation is issued to all who are interested to attend.

* * *

The American Association of Engineers has grown so fast during the last six months that the national headquarters of the association in Chicago has outgrown its quarters. Within the next two or three weeks the headquarters will be moved from the present location at 29 S. La Salle St., to the Nepeenauk Bldg., at 63 E. Adams St., where a lease has been taken on 6000 square feet of office space. The Chicago chapter, which has over 1100 members and which is now the largest engineering society in Chicago, will take over the space vacated by the national headquarters of the association.

* * *

The University of London has announced that it will establish degrees in commerce. It is proposed to institute a three-year course of study leading to the degree of Bachelor of Commerce. The addition of a minimum of two years' practical experience in the particular trade or industry selected would qualify the candidate for the degree of Master of Commerce. The subjects of study comprise organization of industries, banking, trade and transportation, economic developments of the British Empire and of the chief foreign countries, commercial law, and statistical methods. In addition, the student will specialize on certain subjects during the second and third years, according to his own choice.



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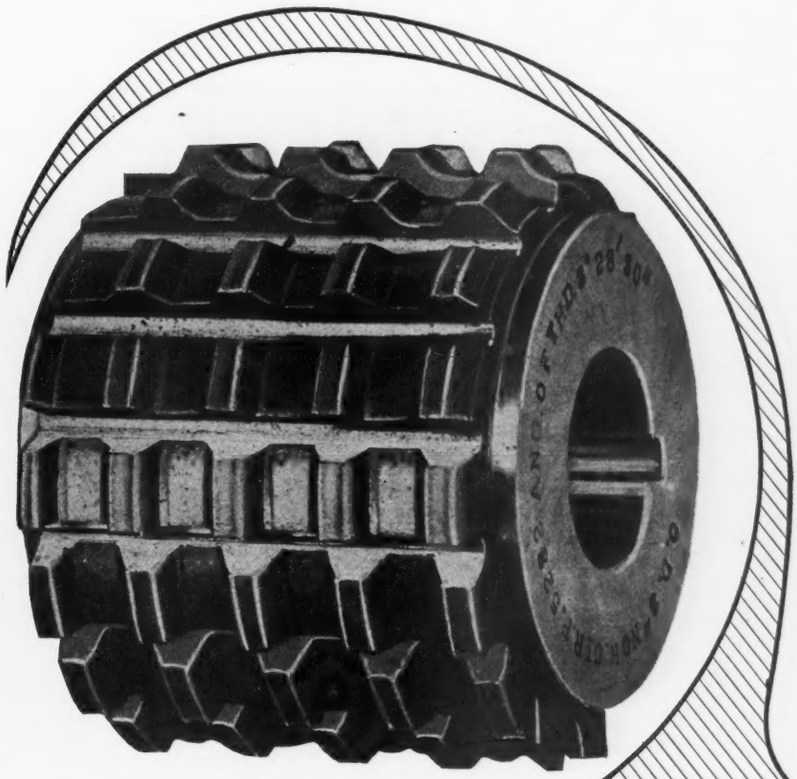

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RIGHTS CONFERRED BY PATENTS

By CHESLA C. SHERLOCK

Patent rights are so often misunderstood that it is advisable to discuss them briefly, particularly from the standpoint of the patentee. It is true that the effort necessary to secure a patent often seems to be worth more than the grant but a good invention more than pays for the trouble.

A patentee becomes the immediate possessor of three individual rights which are absolutely unassailable and in which the Federal Government will protect him for a period of seventeen years. Briefly, he has the right to prohibit others from making, using, or selling the invention during that time. These are not the only rights which the patentee acquires, but they are the principal ones. Other rights are merely incidental to these and necessary to the full enjoyment of the three fundamental rights. Among the additional rights are the right to injunction against further infringement and to recover profits on all articles already made; and the right to restrict making, using and selling the article in any manner desired.

The Right of Restriction in Making, Using and Selling an Article

These secondary rights are almost as valuable as the principal ones. Particular attention is directed to the right to restrict the making, using and selling of the article in any manner desired. This is a matter seldom understood by the patentee. No better example of the true rights of the patentee can be cited than the example of a safety razor. This razor is sold to retail dealers at about $3 with the agreement that it must be resold to the consumer at $5. Any cut in price will amount to an infringement of the patent and render the dealer liable upon that basis. Furthermore, the retailer signs a contract whereby he virtually acknowledges the validity of the patents under which the razor is made, so that he can never attack the company on that score. In the case of the blades, a similar agreement exists, but additional restrictions are placed upon the user of the blade to the extent that to resharpen the blade will be an infringement of the patent and render the purchaser of the blade liable as such. The courts have upheld this right on the part of the company making the razor, saying that the patentee has the right to restrict the making, using, and selling of his patented article in any manner he desires.

A case of interest along the same line is one in which the question of fixing resale prices through wholesalers was decided. In this case, the patentee sold his articles to wholesalers and attempted to fix the price at which retailers could sell to the general public. One of the retailers cut prices. Action was promptly started against the retailer for infringement, but the latter contended that he was within his rights and that the patentee had no right to control prices through more than one party, and that such a grant of authority would amount to restraint of trade. The court adopted the retailer's view of the matter, so it is a matter of law now that retailers can no longer be held as infringers if they cut the selling price, provided the article has not come to them directly from the patentee. Manufacturers and others owning patents can get around this decision, and doubtless will, by establishing their own branch houses and eliminating all middlemen, so that they deal directly with the retailers themselves. Then they can control the resale price to the public.

The Right of the Patentee to License Another to Use His Invention

Another very important right exercised by the patentee is that of licensing his invention to others, thereby keeping a direct hold on the article and restricting its use to his own desires. The patentee unquestionably has the right to license others to use his invention, and he may restrict them in the use of the article in almost any conceivable manner. In speaking of this matter, one court said: "Within his domain the patentee is czar. The people must take the invention on the terms he dictates or else let it alone for seventeen years. This is a necessity from the nature of the grant. Cries of restraint of trade and the impairment of the freedom of sales are unavailing, because for the promotion of the useful arts the constitution and the statutes authorize this very monopoly." This is a point seldom realized by patentees. A patent is a *monopoly*, and the most absolute monopoly that can be created in law.

A patent is personal property, and cannot be taken away from the patentee or his assigns, except by due process of law, which in this case, means constitutional decrees of the courts. A patent cannot be seized under a writ or other execution under the common law, although it may be attached by a creditor's bill in equity, in default of payment of a judgment so obtained.

The patentee must give notice to the public that the article he is selling them has been patented. He must plainly stamp each article made with notice that it is patented. He may continue to so mark the articles even after the patent has expired, but to so mark an article which has not been patented is a criminal offense, punishable by a $100 fine, one-half of which goes to the person bringing the action.

Joint Ownership of Patents Different from Joint Invention

Where several parties own a patent, an interesting situation arises. Any party may sell his rights or dispose of them in whatever manner he desires, absolutely independently from the others, even if the relative interest is unbalanced. Where a patentee so disposes of a portion of his patent by means of a license, it is interesting to note that the licensee does not become an owner of a part of the patent, even in the most limited sense of ownership. A licensee has absolutely no rights of ownership and must not be considered to have, even though the license grants him the right to make, use and sell the article in a limited sense.

Where there are joint inventors, the patent may be taken out in the name of both, but where it is taken out in the name of two parties when one of them is in fact the sole inventor, the patent is invalid. This often arises in cases where an employe invents a new machine and the employer furnishes the money. Both feel that their own interests must be protected, so they take out the patent in their joint names. Unless the employer is an actual co-inventor, the patent as issued is invalid. It is possible for only the inventor to receive the patent in his name, but he may in turn assign all or part of it as he desires, and the employer's interest will be fully protected by entering into a contract with the employe, whereby the latter is to assign a certain portion of the patent or all of it, as the case may be, to the employer as soon as it is issued from the Patent Office. This statement concerning joint inventors must not be confused with joint ownership. There may be joint ownership in a patent, but that is radically different from joint invention.

The purpose of the Government is to grant the patent, and the monopolistic rights going with it, to the actual inventor. One man may merely have the idea of the invention and go to another and have him make the necessary machinery to carry it out, but the first party acquires the patent rights because he is deemed the real inventor. If the man hired to put the plan into execution adds minor improvements of his own, they become the property of the first party, unless they amount to new inventions in themselves. Thus the Government protects those of limited mechanical skill in their conceptions.

* * *

The American Zinc Institute recently formed, has, as one of its objects, to free zinc from its many nicknames, and is making an effort to discourage the use of such names as spelter, blende, jack, and like misnomers. The institute has now over 140 members representing practically every zinc mining and zinc smelting interest in the United States. Many trade journals, the United States Geological Survey, and the Bureau of Mines have already agreed to call zinc by its right name.

CINCINNATI CUTTER GRINDERS

"It's the handiest little grinder I ever came across, and the best equipped with REAL attachments," said the toolroom foreman.

This Cincinnati grinder at the plant of the Consolidated Mfg. Co., Toledo, not only grinds all the cutters for more than a dozen Cincinnati millers but does a lot of tool and gage work besides. That's the kind of cutter grinder every shop wants.

Cincinnati cutter grinders are made in two sizes; the No. 1 Plain mentioned above, and the No. 1½ Plain and Universal. Both are fully described in the New Cincinnati Grinder Book—a complete treatise on cutter grinders and successful tool grinding. Write for a copy.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI **OHIO, U. S. A.**

MACHINES FOR EMBOSSING METAL SHIPPING TAGS

Thousands of freight and express shipments are lost annually due to inadequate marking of their destination. Linen and paper tags are commonly used for this purpose and it frequently happens that the tags become torn off and lost, or else are so covered with oil, grease, or dirt that they are illegible. As a result, it is impossible for the article to reach the customer and it is sent to the claim department of the express or railroad company. Often a machine manufacturer receives an order for a repair part, and after completing the part in record time, it is shipped to the customer. Then, if in some manner the tag becomes lost or unreadable during the transportation, much time elapses before the impatient customer receives the part, if he receives it at all. In many such cases the customer is likely to intimate that the article had never been shipped, and as a result business relations become strained.

Metal tags having the destination of the article stamped or embossed thereon, are a vast improvement over paper and linen ones. In order to produce such tags the machines shown in the accompanying illustrations have been developed by James H. Matthews & Co., 3946 Forbes St., Pittsburg, Pa. The machine illustrated in Fig. 1 was designed for producing a quantity of identical tags. The embossing is done by means of steel type which is set in the lower holder *A*. The holder is removed from the machine in order to set the type. The upper holder *B* contains a block of wood on which an impression of the type is made, after which it serves as a female die. This impression is made after the lower holder has been placed in position, by operating the ram several times by means of a foot-lever. The metal tags are placed on the lower holder and a completed tag is produced at each stroke of the ram. Trademarks, export symbols, or any style of printing can be set up as required. It is stated that a boy can reset the type in from five to ten minutes, and that between 4000 and 5000 tags can be embossed per day.

Fig. 2 shows a machine designed for cases where only one or two identical tags are required at a time. In this machine the tag is embossed letter by letter, the action being similar to that of a typewriter. Two or three tags can be embossed at the same time by simply placing them under each other. The machine is equipped with a device that automatically brings the tag in the proper position to be embossed. The desired type is brought into the stamping position by turning the handwheel *A* in the proper direction, after which the embossing operation is performed by pushing down a handle. Dial *B*, which contains all the numbers, letters, and other characters that can be embossed on the machine, is provided with a marker which points to a character on the dial similar to the one which is in the position to be embossed when handwheel *A* is brought into position.

Fig. 1. Machine on which a Completed Tag is produced at Each Stroke

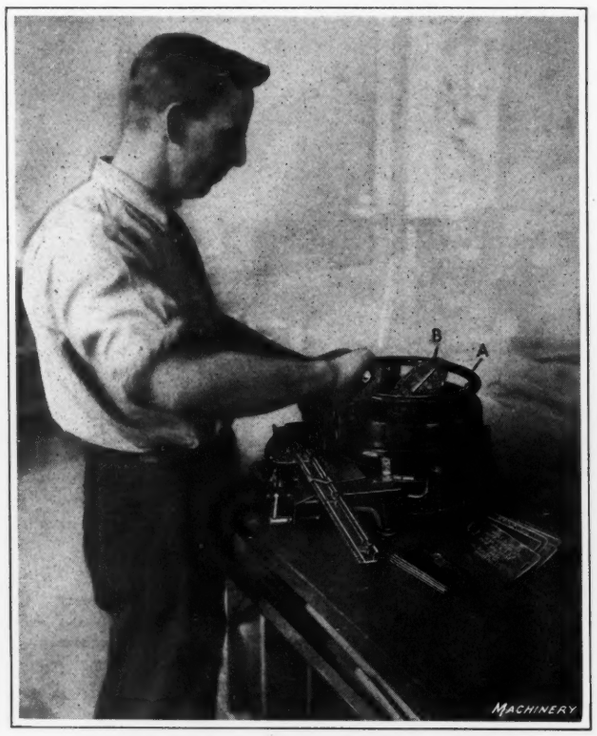

Fig. 2. Machine on which the Embossing Action is Similar to that of a Typewriter

The metal tags embossed on these machines may also be used for identifying work that is in the process of manufacture. They may be attached to material that must go through a pickling plant, an annealing furnace, or some similar treatment, and after being subjected to these conditions, the tags will still be legible. In this way, material on one order can be treated along with material on another order without danger of the orders becoming mixed.

* * *

WESTINGHOUSE COMPANY BUILDS HOMES FOR EMPLOYES

Owing to the difficulties experienced by the employes of the Westinghouse Electric & Mfg. Co. in obtaining homes near the East Pittsburg works, the company has resumed its home building activities that were postponed during the war. Forty-eight new houses are now under construction and it is expected ultimately to erect, on the tract of 109 acres on which these homes are now built, homes for 600 families. The houses are of first-class construction, built from brick with hollow tile backing, and have concrete cellars and cement porches. They consist mainly of five, six, and seven rooms, and will be sold at cost on easy terms to the employes of the company. In the past the Westinghouse company has constructed a great number of homes for its employes and also owns a number of homes and apartments which are rented to the men in the plant. An effort is made, however, to have the men acquire their own homes, and this, without question, is one of the best steps toward assisting the workers in becoming stable, self-respecting men and home-owners who cannot easily be swayed by unsound economic doctrines. If all manufacturing enterprises of a size large enough to warrant the undertaking would attempt to do this, they would render a great public service.

It Is a Pleasure to Produce a Boring Fixture Like This

Forty-two holes up to 4″ diameter and averaging 4″ deep—and dimensions, any one hole to any other, all check up within 0.001″. This fixture is a good example of the work done by the Gem City Machine Co. Dayton—it is a good example also of what we mean when we talk about *Lucas Boring Machine Precision.*

LUCAS MACHINE TOOL CO. NOW AND ALWAYS OF **CLEVELAND, OHIO, U.S.A.**

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NEW BOOK ON DRILLING PRACTICE

MODERN DRILLING PRACTICE. By Edward K. Hammond. 230 pages, 6 by 9 inches; 137 illustrations. Published by THE INDUSTRIAL PRESS, 140-148 Lafayette St., New York City. Price, $2.50.

The material published in this book was collected by the author, as associate editor of MACHINERY, and comprises a study of drilling practice in a great number of plants throughout the United States. A number of important changes have been made during recent years in the methods of drilling holes in interchangeable manufacture. A great increase has been made in the speed at which twist drills are driven. Various types of universal or special multiple-spindle drilling machines and auxiliary drill heads are more generally used than formerly, and semi-automatic drilling machines are also successfully employed. All these developments in drilling practice have been introduced with a view to increasing production; and in preparing this book, the author's object has been the same. The methods described are those that have been thoroughly tried out under actual manufacturing conditions.

In addition to the description of methods for obtaining maximum production by drilling machines, many associated subjects, such as the proper grinding of twist drills, are dealt with, because of their great importance. Different types of drills, drill sockets, and drill chucks are also described, and speeds and feeds for drilling are dealt with in detail.

All mechanics are familiar with the various types of drilling machines generally used in machine shops. On this account nothing beyond a brief description of the essential features of each type has been included, because detailed descriptions would be of no practical value in a book of this kind. Examples of good practice in operating each type of machine are completely illustrated and described, however, giving information concerning the material, the size of holes being drilled, the speed and feed at which the operation is performed, and the rate of production which is obtained.

The book is divided into ten chapters, headed as follows: General Types of Drilling Machines and Their Application; Multiple-spindle Drilling Machines of Standard and Special Design; Automatically Controlled Drilling Machines of Special Design; Speeds and Feeds for Drilling; Types of Drills and Drill Sockets; Types of Commonly Used Drill Chucks; Drill Grinding; Drilling Machines Applied to General Manufacturing Operations; Jigs, Fixtures, and Special Tools for Drilling Machines; Deep-hole Drilling.

The book should be of considerable value to men responsible for the production obtained in the drilling department of a machine shop, whether in the capacity of superintendents, mechanical engineers, or foremen, as well as to drill press operators who are anxious to increase their knowledge of modern drilling methods. Designers and draftsmen engaged either in drilling machine design or in the design of jigs and fixtures for work performed by drilling, will also find considerable information of value to them in this book.

* * *

A. S. M. E. SEPTEMBER MEETING

The New York section of the American Society of Mechanical Engineers held its regular monthly meeting at the Engineering Societies' Building, 29 W. 39th St., New York City, September 17, at which meeting the subject of "Industrial Unrest" was dealt with in an address by Dr. William M. Leiserson, who gave a review of the present conditions in the industries with particular relation to labor difficulties. A number of other speakers joined in the discussion.

OBITUARIES

OTTO A. RUEMELIN, works manager and second vice-president of the Pawling & Harnischfeger Co., Milwaukee, Wis., died September 1. Mr. Ruemelin had been associated with the Pawling & Harnischfeger Co. for thirty years, having started in the shop as an apprentice. After several years as journeyman, he was promoted successively to the foremanship of various departments. His energy, ability, and kindly nature made his rise rapid from assistant superintendent to superintendent and finally to works manager, which position he held since 1912.

PERSONALS

H. F. HIMES, formerly with the Dimler-Himes Tool Co., Dayton, Ohio, is now manager of the Dayton branch of the Wayne Machinery Co., 18 W. 2nd St.

HERCULES SMART, formerly manager of the New York office of the Illinois Tool Works, Chicago, Ill., has been appointed manager of the company's Detroit store, succeeding D. J. Rice.

MARSHALL J. ROOT, formerly president of the Seneca Falls Mfg. Co., Inc., Seneca Falls, N. Y., has disposed of his interests, and is now vice-president of the Fairbanks Co., New York City.

H. M. THOMAS, for many years superintendent of the Anderson Engine Co., 4036 N. Rockwell St., Chicago, Ill., is now production engineer of the United States Tractor & Machinery Co., at Menasha, Wis.

ERWIN L. MALONE has been appointed Cleveland district representative of the Hess Steel Corporation, Baltimore, Md. His headquarters will be located temporarily at the Cleveland Athletic Club, Cleveland, Ohio.

H. C. JONES, for several years connected with the Lodge & Shipley Machine Tool Co., Cincinnati, Ohio, as special European representative, has entered the sales organization of the J. R. Stone Tool & Supply Co., 997 Woodward Ave., Detroit, Mich.

JOHN M. HOWETT, formerly of the Cincinnati and Chicago offices of the Pratt & Whitney Co., has opened a sales office at 16 W. 2nd St., Dayton, Ohio, to handle a full line of machine, production, and small tools under the firm name of John M. Howett.

E. V. WENZELL, for more than ten years demonstrator and sales representative for the Norton Co., Worcester, Mass., has become affiliated with the Modern Tool Co., Erie, Pa., as western representative, and will be stationed at the company's Chicago store and office, 32 N. Clinton St.

S. E. WEAVER, for several years manager of the Union Twist Drill Co. in eastern Pennsylvania and the southern territory has joined the sales force of the Davidson Tool Mfg. Corporation, 118 Maiden Lane, New York City, and will represent that company in a similar capacity in his old territory.

GEORGE W. CRANE has been made president of the Seneca Falls Mfg. Co., Inc., Seneca Falls, N. Y., succeeding Marshall J. Root. Mr. Crane was formerly associated with the Pierce, Butler & Pierce Mfg. Corporation, manufacturer of boilers and radiators and jobber of plumbing supplies, as assistant sales manager.

ROBERT K. GREAVES, for several years connected with H. Boker & Co., Inc., as manager, has been made sole United States agent for Sanderson Bros. & Newbould, Ltd., Sheffield, England, manufacturers of high-speed tool and alloy steels. Mr. Greaves will be located at Machinery Hall, 549 W. Washington Blvd., Chicago, Ill.

HARRY M. GILES has been appointed general superintendent of the South Philadelphia works of the Westinghouse Electric & Mfg. Co., succeeding Oscar Otto, who was killed in an automobile accident. Mr. Giles has risen from the ranks in the organization, and has been, for a number of months past, superintendent of marine erection.

HARRY J. LINDSLEY, who has been western sales manager of the Bound Brook Oil-less Bearing Co., Bound Brook, N. J., for the last seven years, and WILLIAM F. JENNINGS, who has been eastern sales manager for the last five years, have been made vice-presidents and will continue to serve the company and its customers the same as in the past.

L. T. FREDERICK has recently become associated with the Chicago Mica Co., Valparaiso, Ind., as consulting engineer and production manager. Mr. Frederick was formerly process engineer of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., and has had a wide experience in the manufacture and application of all lines of electric insulation.

W. L. KERLIN, who was in the United States Army Service as Major in the Mobile Ordnance Unit on the French front and who previously had considerable experience in the machinery and machine tool line, is now representing the P. W. V. Automatic Machine Corporation of Fitchburg, Mass., in the company's New York City office at 143 W. 40th St.

H. EARL SWEITZER has become connected with the Allsteel-equip Co., Aurora, Ill., as sales manager in charge of sales and advertising. For the past year Mr. Sweitzer has been assistant sales manager, and previous to that was advertising manager for several years with the Appleton Mfg. Co., Batavia, Ill., manufacturer of farm implements and tractors.

A. L. DELEEUW has resigned his position with the Singer Mfg. Co., Elizabethport, N. J., and has opened an office in the Singer Building, 149 Broadway, New York City, in a consulting engineering capacity. Mr. DeLeeuw will devote himself to planning the buildings and equipment of industrial plants, and will make a specialty of machine shop problems with a view to securing economical production.

SCREWS

MACHINE, WOOD, CAP, SET, LAG, ETC.

We Have the Assortment and the Quantity

Let us figure on your next specifications. We have managed to "take care" of some very large concerns both in price and delivery.

HAMMACHER, SCHLEMMER & CO.

HARDWARE, TOOLS AND SUPPLIES

NEW YORK SINCE 1848 4th AVENUE and 13th STREET

DR. THOMAS M. LEGGE, chief medical inspector of factories, in Great Britain, has been invited by Harvard University to give a course of lectures under the auspices of the school of public health of Harvard University and the Massachusetts Institute of Technology, and the division of industrial hygiene. Dr. Legge will lecture in Boston during November on the following subjects: Twenty Years' Experience of the Notification of Industrial Disease; Twelve Years' Experience of Workman's Compensation Act and Industrial Diseases; Medical Supervision in Factories; Industrial Poisons and their Prevention; Anthrax; Fumes and Gases; and Industrial Fatigue.

A. A. SCHNEIDER, formerly with the Raw Materials Department of the Midvale Steel & Ordnance Co. and the Cambria Steel Co., has been appointed manager of the newly created Raw Materials Division of the American Steel Export Co., 3004 Woolworth Bldg., New York City. Prior to entering military service in 1917 as a Lieutenant of the Field Artillery, Mr. Schneider for several years had been assistant to H. F. Black of the Midvale Steel & Ordnance Co. and the Cambria Steel Co., and has had a wide experience in the raw materials and metals trade. He will handle imports, exports, and domestic sales of pig iron, manganese, chrome and low-phosphorus iron ores, ferro-alloys, coal, and coke.

COMING EVENTS

October 1-4—Eighth annual safety congress of the National Safety Council in Cleveland, Ohio. Offices of the council, 168 N. Michigan Ave., Chicago, Ill.

October 15-16—Annual convention of the National Machine Tool Builders' Association in New York City; headquarters, Hotel Astor. General manager, Charles E. Hildreth, Worcester, Mass.

October 30—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137 Sibley Block, 328 Main St., E., Rochester, N. Y. Secretary, O. L. Angevine, Jr., 547 Arnett Blvd., Rochester, N. Y.

February 2-6, 1920—First annual mechanical inspection equipment exposition and convention of the American Society of Mechanical Inspectors at the Hotel Astor, New York City. Secretary, Henry F. Winter, 35 W. 39th St., New York City.

May 12-15, 1920—Seventh national foreign trade convention in San Francisco, Cal. Secretary of the National Foreign Trade Council, O. K. Davis, 1 Hanover Square, New York City.

BOOKS AND PAMPHLETS

Exercises in Lettering—Slant Gothic. By George G. Greene. 31 pages, 2½ by 5 inches. Published by the Bruce Publishing Co., Milwaukee, Wis. Price, 10 cents.

This little book is one of a vest pocket series containing instructions for lettering. It comprises sixteen exercises intended to train the student to produce slant Gothic lettering neatly and rapidly.

Constitution and Metallography of Aluminum and its Light Alloys with Copper and with Magnesium. By P. D. Merica, R. G. Waltenberg, and J. R. Freeman, Jr., of the Bureau of Standards. 15 pages, 7 by 10 inches. Published by the Department of Commerce as Scientific Paper No. 337 of the Bureau of Standards, Washington, D. C. Price, 10 cents.

Laboratory Experiments with Direct Currents. By Professor F. E. Austin, 152 pages, 4½ by 7½ inches. Published by F. E. Austin, Hanover, N. H.

The subject matter that is presented in this laboratory manual is the result of the author's experience in the organization of electrical laboratories and the teaching of laboratory courses during a period of over fifteen years. The experiments outlined are designed for students in technical and industrial high schools, as well as those pursuing shorter courses in higher institutions of learning. Questions and problems to be worked out accompany each experiment. The matter covers use and care of millivoltmeters, milliameters, and wattmeters; curve plotting; measurement of resistance; mapping magnetic fields; arc lamp measurements; experiments with potentiometer; measurement of permeability; testing ammeters; and testing shunt generators and motors and direct-current motors.

Dyke's Automobile and Gasoline Engine Encyclopedia. By A. L. Dyke. 960 pages, 6½ by 9¾ inches. Published by A. L. Dyke, St. Louis, Mo. Price, $5.

This is the tenth edition of a comprehensive encyclopedia covering the automobile and gas engine field. The book has been revised and many new subjects are presented in this edition. Included in the new material is information on how to make electric tests of the starting motor, generator, battery, coils, magnetos, etc. The book covers every detail of construction and repair of automobiles and gas engines, and deals with trucks, tractors, motorcycles, airplanes, and airplane engines. The automobile instruction section was prepared with the idea of presenting in clear, simple form the principles upon which gasoline engines and automobiles are built and operated, and explains in detail all that must be understood in order to operate and care for any make of car or gasoline engine. To make clear the modern details of an automobile and its parts, it seemed necessary to illustrate and describe the early types of cars and gradually work up to the more modern types. The subjects covered are Automobile Assembly; Drive Systems; Steering Assembly; Axles, Differentials and Bearings; Clutches, Universal Joints, and Transmissions; Engines; Carburetion; Cooling and Lubrication; Ignition—Coil and Battery; Ignition—Magnetos; Electric Systems; Operation, Care, etc.; Tables, Specifications, etc.; Tires; Troubles and Remedies; Repairing and Adjusting; and Miscellaneous. The supplements of the book treat of the Ford and Packard Cars, Airplanes, and the Liberty Engine; Wiring Diagrams. The index covers thirty pages.

NEW CATALOGUES AND CIRCULARS

Link-Belt Co., Chicago, Ill. Circular of Link-Belt motor trolley hoists.

Collis Co., Clinton, Iowa. Price list of "Use-Em-Up" and standard types of drill sockets and sleeves.

Peter A. Frasse & Co., Inc., 417 Canal St., New York City. Price list of Frasse cold-finished screw steel and shafting.

Belt-Grip Pulley Co., Buffalo, N. Y. Circular of "Belt-Grip" leather pulleys, leather buffing wheels, and leather rim truck casters.

Detroit Heating & Lighting Co., Detroit, Mich. Circular advertising the Detroit laboratory burner and the Detroit combination gas machine.

United Machine & Mfg. Co., Canton, Ohio. Circular giving dimensions, weights, prices, etc., of "United" standard cast-iron surface plates.

Gisholt Machine Co., Madison, Wis. Circular advertising the Gisholt "Periodograph" for automatically recording workmen's time in the shop.

W. M. & C. F. Tucker, Hartford, Conn. Catalogue 6 (revised edition) covering the complete line of oil-hole covers and cups made by this company.

W. J. B. Slide Ruler Clip Co., 43 Center St., Springfield, Mass. Card advertising the "Safety First Mechanic's Friend"—a clip for holding slide-rules.

Frank E. Fitts Mfg. & Supply Co., 88 Purchase St., Boston, Mass. Circular describing an emery grinder for grinding tools, which is operated by a foot-treadle.

McInnes Steel Co., Ltd., Corry, Pa. Catalogue of McInnes hammered tool steels, listing the various grades and recommending the heat-treatments to be employed.

Stromberg Electric Co., 8 W. 40th St., New York City. Circular entitled "Prosperous Times Are Ahead," advertising Stromberg time recorders for cost keeping.

Liberty Tool Co., Munsey Bldg., Baltimore, Md. Circulars illustrating dolly bars, heading attachments, portable drilling machines, rivet furnaces, and heating torches.

Oliver Machinery Co., Grand Rapids, Mich. Circular advertising the Oliver swing cut-off saws, which are made in many different sizes and styles for different classes of work.

Philadelphia Belting Co., Sixth and Spring Garden Sts., Philadelphia, Pa. Circular advertising "Superpacking"—a leather packing for hydraulic and pneumatic machinery.

E. S. Jackman & Co., Chicago, Ill. Circular listing the uses for which "Blue Chip" high-speed tool and die steel and Firth-Sterling special tool and die steel are adapted.

Smalley-General Co., Inc., Bay City, Mich. Bulletin D, showing typical operations performed on thread milling machines of this company's manufacture, and giving time studies for each.

Green Engineering Co., East Chicago, Ind. Circular containing a reprint of an article, "Characteristics of Illinois Coal and How to Burn It," which gives data on chain grate performance.

Sohm Electric Co., 143 W. Austin Ave., Chicago, Ill. Circular descriptive of the Sohm keyless clocks made in types especially adapted for shops, factories, and industrial use in general.

National Lathe Co., 15 W. Second St., Cincinnati, Ohio. Catalogue O, illustrating and describing the National line of engine, turret, and gap lathes of the geared-head and cone-head types.

St. Louis Machine Tool Co., St. Louis, Mo. Catalogue 16, illustrating and describing the company's line of grinding, polishing, and tapping machinery, and giving specifications for the different sizes.

Richards-Ford Train Control Co., Inc., 403 Drovers and Mechanics Bank Bldg., Baltimore, Md., is desirous of obtaining catalogues of transmission machinery, conveyors, power plant machinery, pumps, etc.

S. F. Bowser & Co., Inc., Fort Wayne, Ind. Folder illustrating and describing a Bowser battery storage system for lubricating oil. These outfits are sold in one, two, three, or four units as required.

Ajax Metal Co., Philadelphia, Pa., has opened a branch office in Cleveland, Ohio, located in the Schofield Building. L. E. Purnell is district manager. The Pittsburg office of the company has been discontinued.

Skelton Tool Co., 406-408 Ash St., Syracuse, N. Y. Folder entitled "Where's Yours Coming From?", describing two new tools produced by the company—the Porter elevating toolpost and the Porter boring-bar.

Goulds Mfg. Co., Seneca Falls, N. Y. Circular entitled "From Paraffin to Paper Pulp and from Tanning Liquor to Tar," advertising Goulds triplex, centrifugal, deep-well, vacuum, rotary, and other types of pumps.

Duntley-Dayton Co., 1416 Michigan Ave., Chicago, Ill. Circular giving information about the Duntley air drill with detachable power unit, which is made in two sizes, having capacities of ¼ and ⅜ inch, respectively.

Wellman-Seaver-Morgan Co., E. 70th St. and Central Ave., Cleveland, Ohio. Bulletin 27, describing the W. S. M. automatic ore unloaders in operation on the Great Lakes. Copies of the bulletin are sent free upon request.

Pangborn Corporation, Hagerstown, Md. Circular entitled "How am I to Know?", reproducing a number of letters of recommendation of Pangborn service as applied to the selection, arrangement, and installation of sand-blast equipment.

Colonial Steel Co., Pittsburg, Pa. Tool Steel Treating Book, containing directions for the heat-treatment of high-speed steel and carbon tool steel. The book also includes lists of tools, and grades of Colonial steel best adapted for their use.

Milliken Bros. Mfg. Co., Inc., Woolworth Bldg., New York City. Catalogues 10 and 11, descriptive of Milliken all-steel fireproof buildings, which are constructed under the standardized truss unit system. Copies of the catalogues will be sent free upon request.

National Tube Co., Frick Bldg., Pittsburg, Pa. Bulletin 7 entitled "Manufacture and Advantages of National Welding-scale Free Pipe," comprising a treatise on the manufacture of seamless steel pipe, illustrated with views showing steps in the process of manufacture.

New Departure Mfg. Co., Bristol, Conn. Circulars 114 FE, 115 FE, 116 FE, and 117 FE, descriptive of the use of ball bearings in motor-driven pumps, canvas cushion wheels, electric breast drills, and bearings for wheels of sand mixing machines, respectively.

Electric Furnace Co., Alliance, Ohio. Booklet 13-B, containing a reprint of a paper entitled "Resistance Type Electric Furnaces for Melting Non-ferrous Metals," presented by T. F. Baily before the June meeting of the American Institute of Chemical Engineers, Boston, Mass.

James H. Matthews & Co., Pittsburg, Pa. Catalogue of Matthews "Quantitag" and "Unitag" machines for embossing metal tags by the use of steel type. With these machines, durable tags can be quickly and easily embossed with any desired marking, which it is practically impossible to obliterate.

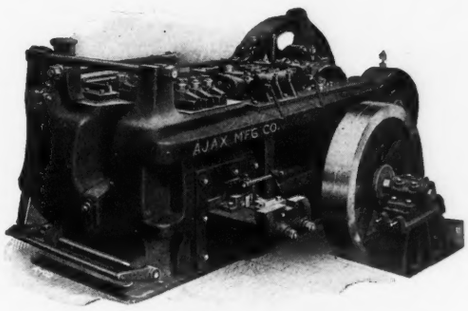
Gisholt Machine Co., Madison Wis. Catalogue comprising reprints of advertisements showing work done on Gisholt turret lathes, grinders, and boring mills, and containing information concerning the history and activities of the company. Folder ATL1, illustrating three jobs performed on Gisholt automatic turret lathes, and giving production time.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Circular 7149, entitled "Electric Arc Welding," describing the field of application of the electric arc welding process and methods employed in modern practice. The book contains much instructive material relative to the process of electric welding and includes sketches showing the correct methods of making various types of welds.

Allied Machinery Co. of America, 51 Chambers St., New York City. Catalogue (Section 11901) of the automatic threading lathes for external and internal thread cutting manufactured by the Automatic Machine Co. of Bridgeport, Conn. Catalogue (Section 14301) of horizontal boring, drill-

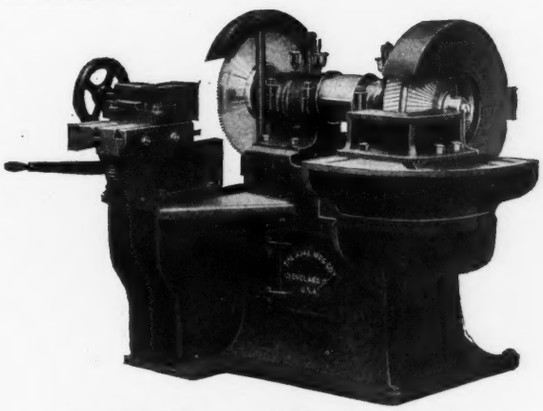
AJAX

(Trade Mark Registered)



Ajax Steel Bed Upsetting and Forging Machine

An indispensable machine for the Forge Plant, for the production of all kinds of car and locomotive forgings, giving maximum production and minimum maintenance cost.



Ajax Hot Saw and Burring Machine

These tools are rapidly developing to be a very essential part of the forge shop equipment for economical production in connection with Upsetting Forging Machines. Finished forgings are sawed from the hot bar and the flash is hot milled or the stock can be prepared preparatory to upsetting.

Machines That Reduce Forge Shop Costs

Ajax Machines like these are saving thousands of dollars yearly in the forge shops of leading railroads here and abroad.

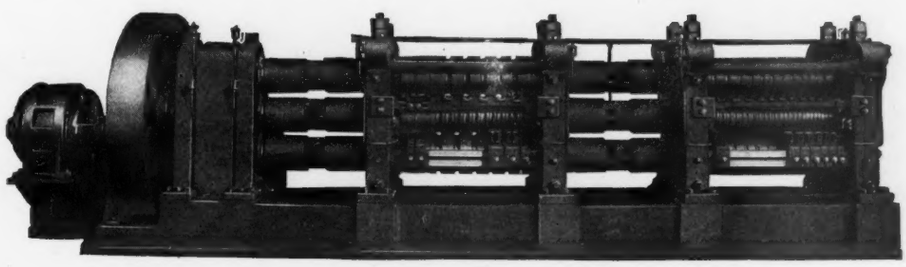
Over two-thirds of the forging machines in the world are Ajax-made.

Their value for rapid production of forgings of all kinds has been definitely proven by years of hard practical service.

There is an Ajax Machine which exactly suits *your* forge shop problems. Send us samples or blue prints and we will give you detailed figures on how much an Ajax Machine will save you.

THE AJAX MFG. COMPANY
Cleveland, Ohio

1369 Hudson Terminal, New York City
621 Marquette Building, Chicago, Illinois



Reclaiming Rolls

By re-rolling scrap pieces of iron and steel bars to form good stock of smaller size, rolls of this type are saving railroad companies and large factories many thousand dollars yearly.

Makers of

Automatic Feed Rivet and Bolt Headers, Hand Feed Rivet and Bolt Headers, Continuous Motion Heading Machines, Bulldozers, (High Speed and Standard), Hot Sawing and Burring Machines, Axle Upsetting Machines, Reclaiming Rolls, Universal Forging Machines, Hot Pressed Nut Machines, Taper Forging Rolls.

ing, and milling machines of the table type, manufactured by the Lucas Machine Tool Co. of Cleveland, Ohio.

Hyatt Roller Bearing Co., Metropolitan Tower, New York City. Engineering bulletin 125, treating of the construction of Hyatt roller bearing hangers for use on lineshafting, and giving list prices for the various sizes. The bulletin also gives transmission data on the size of shafting for transmitting different horsepowers, proper speed of lineshafting, and other related information.

American Stainless Steel Co., Oliver Bldg., Pittsburg, Pa. Circular describing the properties and uses of "Stainless" steel, which is said to withstand the action of the most common corrosive agents without the development of permanent erosion or a stain, and also to withstand high temperatures while exposed to air or other gases without scaling or pitting. These properties adapt the steel for such uses as cutlery, acid-handling machinery parts, furnace parts, etc.

J. T. Slocomb Co., Providence, R. I. Catalogue 16, covering the complete line of tools manufactured by the company, which comprises inside and outside micrometers and center drills. This catalogue also includes a publication of the company known as the "Measuring Book," which contains suggestions regarding accurate and economical measuring by the use of micrometer calipers. The Measuring Book contains, in addition, instructions for reading the micrometer, making proper allowances for various classes of fits, and other information of interest and value.

Taft-Peirce Mfg. Co., Woonsocket, R. I. Bulletin 107, illustrating and describing Simmons unit-pole magnetic chucks and their application for holding a wide variety of work. Bulletin 108, entitled "Take it to Taft-Peirce," containing a description of the Taft-Peirce contract service and plant. Bulletin 109, giving dimensions and price lists of Taft-Peirce plug, screw, and snap gages and milling cutters. Bulletin 110, illustrating and describing Taft-Peirce production and inspection tools, including taper gages, sine bars, V-blocks, equalizing jaws, parallels, adjustable knees, angle-irons, etc.

Clark Equipment Co., Buchanan, Mich., has issued a publication entitled "Putting Mettle into Metal" which should be of interest not only to users of twist drills but also to those who believe that a factory should be artistic in appearance and should have beautiful surroundings as well as other provisions for the comfort and happiness of the employes. The book contains a description of the plant in which the "Celfor" twist drills are made, and the illustrations show how the grounds have been beautified by trees and gardens. Other views show the activities of the company in providing for the diversion and welfare of its employes, among which may be mentioned the organization of a theater and orchestra, the construction of attractive homes for the employes, and the establishment of an up-to-date hospital. Various steps in the process of manufacture of "Celfor" twist drills are also illustrated.

TRADE NOTES

Scully-Jones & Co., 647 Railway Exchange Bldg., Chicago, Ill., have been appointed sales representatives for the Wetmore expanding reamer in the Chicago district, embracing Illinois, southern Wisconsin, Iowa, and northern Indiana.

Dickey Steel Co., Inc., Woolworth Bldg., New York City, has been appointed sales representative for the New York and Philadelphia district of the Worcester Pressed Steel Co. of Worcester, Mass., manufacturer of hot- and cold-rolled strip steel, and light and heavy metal stampings.

Davidson Tool Mfg. Corporation, 118 Maiden Lane, New York City, maker of "Davidsonized" high-speed steel milling cutters, has opened a factory sales office and stock-room in the Garfield Building, 864 Woodward Ave., Detroit, Mich., for the convenience of its Michigan customers. Alexander Hart, Jr., is in charge of the new office.

Rickert-Shafer Co., 612 W. 12th St., Erie, Pa., manufacturer of thread-cutting tools and machinery, is erecting a two-story brick and steel addition to its plant that will double the present floor space. The addition will be given over to the manufacturing of the company's expanding diehead and will be ready for occupation December 1.

Weber & Scher Mfg. Co., 24 Scott St., Newark, N. J., manufacturer of dies, jigs, fixtures, gages, special machinery, and appliances has recently organized an engineering department. The company is desirous of obtaining catalogues for its files covering small tools, machine tools, appliances, equipment, stock parts, materials, and supplies.

Driver-Harris Co., Harrison, N. J., is now selling its wire rope products direct to the trade instead of through its former selling agents. The company has increased its facilities to include all grades of rope in 6 by 7, 6 by 12, and 6 by 19 construction, such as drilling cable, elevator rope, haulage rope, sand lines, etc., in all sizes up to ¾ inch.

American Cement Machine Co., Inc., Keokuk, Iowa, desires to obtain catalogues of manufacturers and jobbers in iron, steel, and mill supplies. The company is enlarging its plant and putting in additional machinery and it would appreciate two copies of the latest catalogues from manufacturers in these lines, together with price list, for use in its engineering and purchasing departments.

Victor Tool Co., Waynesboro, Pa., has recently appointed the J. R. Stone Tool & Supply Co., 997 Woodward Ave., Detroit, Mich., its exclusive agent for the state of Michigan to handle the company's entire line of self-opening die-heads, collapsible and adjustable taps, reamer-holders and nut facing machines. A stock of these tools will be carried in the Detroit office in order to serve the trade promptly.

Buerk Tool Works, 38-42 Pearl St., Buffalo, N. Y., has started in the business of making tools, dies, jigs, fixtures, and special machinery. Hans Buerk, manager and sole owner, was connected with the Pierce-Arrow Motor Car Co., Buffalo, N. Y., for ten years as supervisor of tools, and for the past two and a half years has been factory manager of the Columbus Die, Tool & Machine Co., Columbus, Ohio.

T. P. Walls Tool & Supply Co., Inc., 75-77 Walker St., New York City, has been made eastern agent for the Advance Tool Co. of Cincinnati, Ohio, whose line includes milling cutters, gear-cutters, reamers, end-mills and lathe mandrels. The company has also been made agent for the Maxf Grinding Wheel Works of Chester, Mass., whose line includes all shapes and sizes of grinding wheels for various machines and operations.

Robert K. Greaves & Co., 549 W. Washington Blvd., Chicago, Ill., is a concern which has recently been formed by Robert K. Greaves, who for several years was manager of both the eastern and western offices of H. Boker & Co., Inc. Mr. Greaves has been appointed the sole United States agent for Sanderson Bros. & Newbould, Ltd., Sheffield, England, and will carry a large stock of that company's high-speed tool and alloy steels in all grades.

Independent Pneumatic Tool Co., Chicago, Ill., manufacturer of "Thor" pneumatic and electric tools, exhibited at the American Railway Tool Foremen's Association's convention in Chicago, August 27 to 29, a complete line of "Thor" pneumatic and electric tools for drilling, reaming, tapping, flue-rolling, wood-boring, chipping, calking, beading, and driving rivets. Among the new devices exhibited was the "Thor" hose coupling. The exhibit was in charge of F. J. Passino.

Carborundum Co., Niagara Falls, N. Y., has opened branch offices and a warehouse in the Burkhardt Building, Second and Larned Sts., Detroit, Mich. The Detroit branch is under the management of Anthony Dobson, who will have charge of the Detroit sales district. The new offices and warehouse are opened with a view to giving quicker and better service to the users of the company's products in the Detroit district; and a complete stock of carborundum and aloxite grinding wheels, carborundum and aloxite paper and cloth, and other carborundum products will be carried.

Globe Foundry Co., Sheboygan, Wis., has been incorporated by G. F. Honold, Gus A. De Wilde, Jr., and Fred Leicht. The company will engage in the manufacture of machinery and will operate a foundry for casting gray iron and other metals. A tract of land twelve acres in extent has been purchased, and plans are in progress for erecting a building of brick and steel construction. When completed, the new building will be devoted exclusively to foundry work, while the foundry building of the present Globe company, which latter concern is absorbed by the new company, will be converted into a machine shop.

Burton, Griffiths & Co., Ltd., 1-3 Ludgate Square, London, England, which have been associated with the Birmingham Small Arms Co., Ltd., for many years as that company's sole representatives and agents for the sale of high-speed steel twist drills, milling cutters, etc., have exchanged shares with the Birmingham Small Arms Co., Ltd., thus making the interests of the two firms synonymous. The name and management of the business will be the same as heretofore, but this alliance will enable the company to extend its business to other spheres and to execute more important contracts than it has been able to undertake in the past.

Twin-O-Matic Machine & Tool Co., Inc., 160-168 John St., Brooklyn, N. Y., has recently been incorporated to undertake the manufacture of automatic double-end centering machines. The officers are E. R. Barany, president and general manager; A. S. Pinkus, treasurer; and M. L. Burridge, secretary. Spacious quarters have been engaged and up-to-date equipment installed in a modern, concrete, fireproof building. In addition to double-end automatic centering machines, the company will also design and manufacture special and automatic machinery, in which line Mr. Barany has had many years' experience. The company solicits circulars and periodicals for reference purposes.

F. H. Niles & Co., Inc., Woolworth Bldg., New York City, announces the following additions to its force: G. P. Goodman, who for several years has represented the Hisey-Wolf Machine Co. in the East, will take charge of the portable tool department of F. H. Niles & Co., Inc. This company handles not only the Hisey-Wolf line of electric machine tools but also the Canton pneumatic hammers and drills manufactured by the Pittsburg Pneumatic Co. in the East. F. H. Crawford has been appointed secretary of F. H. Niles & Co., Inc., and J. E. Haetten, sales manager. This company, which supplies machine tools and foundry equipment, is experiencing, in general, a constantly increasing demand for its products, and is taking the necessary steps to insure the proper maintenance of its sales service.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., announces that it has awarded its four annual war memorial scholarships of $500 each, after competitive examinations, to Herbert S. Pahren, Cincinnati, Ohio, employed as order clerk in the Cincinnati office of the Westinghouse company, who will take an engineering course at the University of Wisconsin; Arthur Marthens, East Pittsburg, Pa., of the cost department of the company, who will take an electrical engineering course at the Carnegie Institute of Technology; Paul O. Langguth, of Wilkinsburg, Pa., a draftsman in the engineering department of the company, who will take an electrical engineering course at the University of Pittsburg; and Andrew P. Lesniak, of Turtle Creek, Pa., employed in the production department of the company, who will take a mechanical engineering course at the University of Pittsburg.

Electrolytic Oxy-Hydrogen Laboratories, Inc., announces the formation of a sales and manufacturing company under the name of the Electrolabs Co. This will give the company an opportunity to enlarge its organization and to meet the increasing demands of its business. The Electrolytic Oxy-Hydrogen Laboratories, Inc., will continue in charge of the laboratories and will maintain a technical supervision over the work of the new company. The general offices and works of both companies have been moved from Dayton, Ohio, into larger quarters at 2635 Penn Ave., Pittsburg, Pa. The facilities for production of the new plant will be considerably increased. The general sales offices will continue to be located at 15 William St., New York City, and branch sales offices have been opened in the Morris Bldg., Philadelphia, Pa., and in the Merchants Exchange Bldg., in San Francisco, Cal. I. H. Levin will continue in charge of the technical and research work and D. J. Tonkonogy in general charge of sales.

Duff Mfg. Co., Pittsburg, Pa., manufacturer of lifting jacks, announces several changes in its production and engineering departments. W. C. Epstein, until recently in charge of the Production Engineering Division of the Bureau of Aircraft Production at New York, has been appointed general superintendent. Before entering the government service Mr. Epstein was associated with the American Brake Shoe & Foundry Co. of Chicago, Ill. E. M. Webb, recently discharged from the army as first lieutenant of the Ordnance Corps, is now shop superintendent. Mr. Webb was stationed at the Rock Island Arsenal in charge of experimental work, including the development and testing of the French 75-millimeter recoil mechanism. Before being commissioned, he was assistant to the production superintendent of the American Tool Works Co., Cincinnati, Ohio. John Kopf has been appointed manager of the engineering department. Before joining the Duff Mfg. Co. he was connected with the Bureau of Aircraft Production at Dayton, Ohio.

American Car & Foundry Co., 165 Broadway, New York City, has recently made a number of changes in its organization. James M. Buick, formerly vice-president and general manager, has assumed the direction of the sales division of the company and will be known as "vice-president in charge of sales." The office of general manager has been abolished. The production division will be directed by William C. Dickerman, who will be designated as "vice-president in charge of operations." He will be assisted by Frederick A. Stevenson, who will be head of the manufacturing section and will have charge of production in the car plants, rolling mills, and foundries. The engineering, improvement and research, and patent and industrial relations sections will also be under Mr. Dickerman's supervision. The headquarters of both divisions will be at the general offices of the company in New York. Both Mr. Dickerman and Mr. Stevenson have been connected with the company since its incorporation in 1899, having advanced from apprenticeships in the shops to their present positions of responsibility.

Foote-Burt Co., Cleveland, Ohio, manufacturer of single- and multiple-spindle drilling machines, and specialist in the design and manufacture of complete equipments for quantity production, especially for the automobile industry, has been reorganized. A. W. Foote, president and treasurer, and S. G. Burt, secretary, have retired. The Burt estate, representing the preferred stock interest, has been retired. G. E. Randles, formerly vice-president, becomes president, T. H. Doan, Jr., vice-president, W. S. Quinlan, secretary, and S. E. Gross, treasurer. The board of directors consists of the president, vice-president, and secretary, with J. R. Blakeslee and S. L. McCune. The company has been an Ohio corporation since 1906, at which time Mr. Randles joined it, and has been its active head for the past ten years. Prior to this it was a partnership for fourteen years of A. W. Foote and P. H. Burt. This reorganization contemplates the erection of a large modern plant at St. Clair Ave. and the Belt Line Railway, the purpose of which will be to take care of the large and constantly increasing demand for its product. Refinancing and reorganization has been through the medium of the Foote-Burt Machine Co., and the Maynard H. Murch Co., investment brokers.